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THE  
FIELD PRACTICE  
OF  
LAYING OUT CIRCULAR CURVES  
FOR  
RAILROADS.

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By JOHN C. TRAUTWINE,  
CIVIL ENGINEER.

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THIRD EDITION, REVISED.

PHILADELPHIA:

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## PREFACE.

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I HAVE been induced to prepare this little volume almost entirely with reference to the wants of the many young men who desire to qualify themselves for field service in an Engineer Corps. On that account, I have endeavored, by the use of the plainest language, to render the subject intelligible to *them*,—dispensing with that mathematical brevity which would have better accorded with the requirements of those who have already attained to some degree of proficiency in elementary field operations. Still, I trust that it will not prove unacceptable even to the latter.

The Table of Natural Sines and Tangents to single minutes, in a form sufficiently portable for field use, will supply a want which I have myself frequently experienced, not only in the operation of laying out curves, but on many other occasions.

One object in preparing it, was to furnish the profession with a Table that should be not only portable, but *absolutely reliable*. Those whose occupations compel them to resort to the Tables in common use, must have frequently experienced, like myself, the extreme embarrassment which attends the inaccuracies to which they are all subject. So long as a Table is known to contain a single error, the position of which is not ascertained, its employment is attended with doubt in every instance in which we are obliged to refer to it. On this account, I have not only prepared these Tables with the most scrupulous care, while in common type, but in order to render their accuracy a matter of certainty, I had them stereotyped, and afterwards revised three times with the utmost caution. I therefore feel no hesitation in saying that they may be depended upon *absolutely*. The same remark applies to the other Tables contained in the volume.

As Hassler's and Hutton's Tables of Natural Sines and Tangents are those most in use among the profession, it will be desirable to

those persons who possess them, to be able to correct the following errors, which I detected in comparing them.

*In Hutton's Tables, Fifth Edition, 1811.*

Sine of  $6^{\circ} 8'$ , for  $\cdot 1063425$ , read  $\cdot 1068425$ .

Page 328, at top, for 25 Deg., read 40 Deg.

Tangent of  $44^{\circ} 60'$ , for  $\cdot 1000000$ , read  $1\cdot 000000$ .

Tangent of  $41^{\circ} 60'$ , for  $\cdot 8994040$ , read  $\cdot 9004040$ .

*In Dr. Gregory's Corrected Edition (the 8th) of Hutton's Tables, 1838*

Sine of  $49^{\circ} 14'$ , for  $\cdot 7576751$ , read  $\cdot 7573751$ .

*In Hassler's Tables, 1830.*

Sine of  $78^{\circ} 24'$ , read  $\cdot 9795752$ .

Sine of  $20^{\circ} 60'$ , "  $\cdot 3583679$ .

Sine of  $66^{\circ} 19'$ , "  $\cdot 9157795$ .

Sine of  $56^{\circ} 39'$ , "  $\cdot 8353279$ .

Sine of  $55^{\circ} 20'$ , "  $\cdot 8224751$ .

Sine of  $53^{\circ} 4'$ , "  $\cdot 7993352$ .

Sine of  $48^{\circ} 12'$ , "  $\cdot 7454760$ .

Sine of  $45^{\circ} 3'$ , "  $\cdot 7077236$ .

The foregoing I believe to be all the errors in the Natural Sines and Tangents to *whole* minutes, in the respective tables. The discrepancies of 1 in the 7th decimal, I have not considered as errors, as they are occasioned by a neglect of the value of the 8th decimal. For calculating curves, it is not necessary to use more than 4 decimals.

It is scarcely necessary to remark that, beyond  $44^{\circ}$ , the Sines, Tangents, &c. are read *upwards*, from the bottom of the page, using the corresponding column of minutes. To find the sine of an angle exceeding  $90^{\circ}$ , subtract the angle from  $180^{\circ}$ , and take out the sine of the remainder—because the sine of an angle, and that of what it wants of  $180^{\circ}$ , are the same.

In this edition the Tables of Radii and Ordinates have been extended.

JOHN C. TRAUTWINE.

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ERRATA.—None.



# FIELD PRACTICE

OF

## LAYING OUT CIRCULAR CURVES

FOR

## RAILROADS.

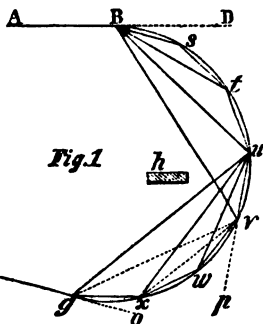
### ARTICLE I.

#### PRINCIPLES OF LAYING OUT CURVES.

##### METHOD 1.

*To lay out a Curve by means of Tangential Angles.*

IF from any point B, fig. 1, in a straight line A D, we lay off any number of equal angles, as D B s, s B t, t B u, u B v, &c., and at the same time make the chords B s, s t, t u, u v, &c. equal to each other, then the points B, s, t, u, v, &c. will be situated in the circumference of a circle, which is tangential to the line A D at the point B.



The first of these angles, D B s, is called the *tangential angle*, as being that by which the curve is connected with the tangent A D; but inasmuch as the others are all equal to it, they also are called tangential angles.

If any obstacle, as h, should prevent our seeing from B farther than to v, the curve may be continued by removing



angles, or angles of deflection, or angles of curvature. In any given circle, the angle of deflection is always precisely double the tangential angle, supposing the chords to be equal. At page 25, we give tables of the angles corresponding to circles of different radii, embracing the limits of railroad practice; and calculated for chords 100 feet in length, that being the usual length for a measuring chain on public works.

N. B. The deflection angle of any curve is equal to the angle  $t c u$ , or  $t c s$ , &c. at the centre of the circle, subtended by one of the equal chords  $t u$  or  $t s$ . This angle at the centre, so subtended, is called the *central angle*. The tangential angle, being always half the deflection angle, is, of course, always half the central angle.

### ARTICLE III.

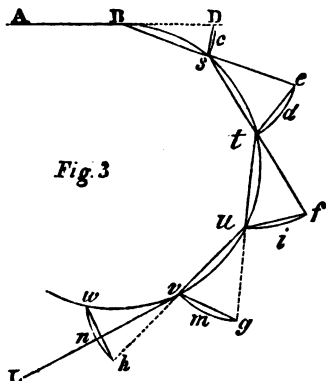
#### METHOD 3.

##### *To lay out a Curve by Eye.*

The deflection angles, fig. 3,  $e s t$ ,  $f t u$ ,  $g u v$ ,  $h v w$ , &c., being double, the tangential angle  $D B s$ , the arcs  $e d t$ ,  $f i u$ ,  $g m v$ ,  $h n w$ , &c., are double the arc  $D c s$ , since the arcs of circles are proportionate to the angles which they subtend; but the chords  $e t$ ,  $f u$ ,  $g v$ ,  $h w$ , &c. are not double the chord  $D s$ , since the chords of arcs are not proportionate to the arcs, or to the angles which they subtend.

The chords  $e t$ ,  $f u$ ,  $g v$ ,  $h w$ , &c., which subtend the deflection angles, are called *deflection distances*; and the chord  $D s$ , which subtends the tangential angle, is called the *tangential distance*.

But although, in any given circle, the deflection distance is not truly twice the tangential distance, yet the difference



is so trifling in large railroad curves, with chords of but 100 feet, that it may generally be neglected in curves of more than 300 feet radius.

In our tables the *precise* length of both will be found for different radii, and for chords of 100 feet.

Having these respective distances, we may frequently trace a curve on the ground by the eye only, with very tolerable accuracy, sufficient for guiding the excavations and embankments, especially on nearly level ground. Suppose, for instance, it be required to lay out in this manner a curve of 5730 feet radius.

First, find by the table, page 25, or by Art. XVI, the deflection distance  $et$  or  $fu$ , &c., corresponding to a radius of 5730 feet for a chord of 100 feet, viz. 1.745 feet; and also the tangential distance  $ds$  .873 of a foot.

Then from the starting point B, and in line with A B, measure B D equal 100 feet; and put a pin at D. Also from B, measure the chord B  $s$ , equal 100 feet; at the same time measuring with a graduated rod, from the pin D, the *tangential* distance D  $s$ , equal to .873 of a foot; and place a stake at  $s$ . The pin at D may then be removed.

Next, make  $se$  equal 100 feet, placing a pin at  $e$ , precisely in line with  $s$  B; also from  $s$  measure  $st$  equal 100 feet; at the same time measuring with the rod from the pin  $e$ , the *deflection* distance  $et$ , equal to 1.745 feet. Place a stake at  $t$ , and remove the pin at  $e$ . In this manner proceed to find other points as far as the end of the curve at  $v$ .

In order to pass from the curve, as at  $v$ , to a tangent  $v$  L, proceed as before, only using the tangential distance  $hn$ , instead of the deflection distance  $hw$ . (See Art. IV.)

This method is abundantly accurate for laying out curves on a canal, or common road; and will occasionally answer very well, when carefully performed, for railroad curves, in the absence of an instrument. Thin straight rods, iron-pointed, and a plumb line should be used for ranging the points in the latter case.

The transit instrument is the best for tracing curves, and running lines generally. I prefer the graduations to run from the same zero, right and left, to  $180^\circ$  each way. There should be two verniers, graduated to minutes; by their means half, or even quarter minutes may generally be estimated with considerable certainty. The telescope revolving in a vertical plane, greatly expedites the laying off of exte-

rior angles, after having first sighted backward to the point behind.

The verniers are sometimes graduated to hundredths of a degree; and this division is, in certain cases, the best; but for *general* purposes, the division into minutes is to be preferred, as all the printed tables of sines, tangents, &c., are calculated for that division.

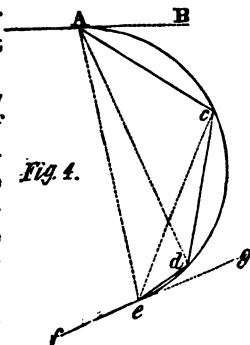
## ARTICLE IV.

### *On Sub-Chords.*

We have hitherto spoken of curves as if they were composed of equal chords, each of 100 feet in length. It frequently happens, however, that at the end of a curve, as at *e*, fig. 4, we are obliged to use a shorter, or sub-chord *d e*, in order to unite properly with the tangent *e f*.

In that case, and *when using Method 1., Art. I., of laying off curves by means of tangential angles*, we must, in order to fix the point *e*, lay off a sub-tangential angle *d A e*, as much smaller than the entire tangential angle *B A c*, or *c A d*, &c., as the sub-chord *d e* is smaller than an entire 100 feet chord, *a c*, *c d*, &c. Thus if the sub-chord be one-half, or one-fourth, &c. of the entire chord, the sub-tangential angle must be one-half, or one-fourth, &c. of the entire tangential angle.

Fig 4.



This method is not mathematically exact, for the reason stated in Art. III. (viz. that the *chords* subtending different angles are not proportional to those angles;) yet, for curves of 300 or more feet radius, and with chords not exceeding 100 feet in length, the error is not observable in practice.

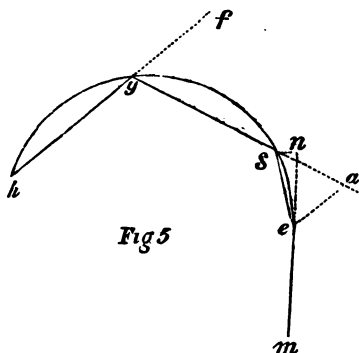
In like manner, when we pass off from a sub-chord, as at *e*, to a second tangent, *e f*, we must place the instrument at *e*, and lay off the same sub-tangential angle *d e g*; or which is better, take sight from *e* to *c*, and lay off the angle *c e g*, equal to the *sum* of a tangential and the sub-tangential angle.



But when using Method 2, Art. II. of deflection angles, or Method 3, Art. III. of deflection distances, we may calculate the sub-deflection angle,  $a s e$ , fig. 5, and sub-deflection distance  $a e$ , formed between a sub-chord  $s e$ , and the extension  $s a$ , of an entire chord  $g s$ , with sufficient accuracy for curves of 300 or more feet radius, and chords of not more than 100 feet, thus:

**Rule.**—Say, as an entire chord of 100 feet is to the sub-chord  $s e$ , so is the deflection angle of the curve, to a certain angle. Add these two angles together and divide their sum by 2, for the sub-deflection angle  $a s e$ , of the sub-chord.

**Example.**—The curve, fig. 5, has a radius of 319.6 feet, and an angle of deflection,  $f g s$ , of  $18^\circ$  for chords of 100 feet. The sub-chord  $s e$  is 25 feet in length; what is the sub-deflection angle  $a s e$ ; and also the sub-deflection distance  $a e$ , for the sub-chord  $s e$ ?



Chord.	Sub-Chord.
Here, as 100	is to 25,

Def. An. of	Certain
100 ft. chord.	Angle.
So is	$18^\circ$ to $4^\circ 30'$ .

The sum of these two angles,  $18^\circ$  and  $4^\circ 30' = 22^\circ 30'$ , the half of which is  $11^\circ 15'$ , the required sub-deflection angle  $a s e$ .

Again, to find the sub-deflection distance  $a e$ , of the sub-chord  $s e$ ; take from the table of sines, the natural sine of one-half the sub-deflection angle  $a s e$ , just found. Multiply this natural sine by 2, and multiply that product by the length of the sub-chord.

**Example.**—The sub-deflection angle is  $11^\circ 15'$ ; one-half of it is  $5^\circ 37\frac{1}{2}'$ , the tabular natural sine of which is .0979, which multiplied by 2, gives .1958; and this multiplied by the sub-chord, 25 feet, gives 4.895 feet, the required sub-deflection distance  $a e$ .

Finally, to find the sub-tangential distance  $s n$ , by means of which to pass from  $e$  to the tangent  $e m$ , say, as 10000

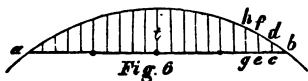
is to the square of the sub-chord in feet; so is the *tangential* distance for a 100 feet chord, to  $s n$ . In this instance, we have as 10000 is to 625, so is 15.69 feet to .980 feet, or  $s n$ .

## ARTICLE V.

### *Ordinates for Entire Chords.*

It would be both tedious, and liable to inaccuracy, to attempt to fix all the necessary points in railroad curves by the foregoing means, which are employed only for entire chords, or for such sub-chords as may be required at the ends of curves.

The best method is to stretch a piece of twine  $a b$ , fig. 6, 100 feet long, between two adjacent chord-stakes, and measure off as nearly as may be at right angles to it, with a graduated rod, the previously



calculated ordinates,  $c d, e f, g h$ , &c., placing pegs at  $d, f, h$ , &c.\* Our table of ordinates, page 28, is calculated for distances apart  $b c, c e, e g$ , &c., of 5 feet; and for all curves likely to occur in practice. The 5 feet distances on the twine should be marked by knots or otherwise; and those at the center, and half way between it and the ends, be further distinguished by tying on pieces of tape.

The 5 feet distances are only used (after the excavations and embankments are finished) for placing pegs to guide the laying of the rails, and then only for very sudden curves; for those of large radii, distances of 10 feet are quite sufficient, or even 25 feet for very easy curves. For guiding the curves of the cuttings and fillings, it is not necessary to place the stakes nearer than 50 feet apart; unless for those of less than about 1000 feet radius, when they may be placed 25 feet apart. Ordinates for radii intermediate of those in the table, may either be calculated by the rules given further on; or they may be taken proportionally intermediate of the tabular ones, with sufficient accuracy for practice.

### *Ordinates for Sub-Chords.*

These may readily be calculated *approximately enough*

\* On the tops of these stakes, small tacks are driven to define the precise point in the curve.

for railroad practice, for curves of over 300 feet radius, and for chords not exceeding 100 feet, thus: In a circle of given radius, not less than about 300 feet, the ordinates of an entire 100 feet chord may be assumed to be to those of a sub-chord, as the square of the chord is to the square of the sub-chord.

In all our tables the chord is supposed to be 100 feet, the square of which is 10000; the rule therefore becomes, as 10000 feet : to square of sub-chord in feet :: Ord. of Chord : Ord. of Sub-chord *approximately*.

*Example.*—In a curve of 5730 feet radius, the middle ordinate of a 100 feet chord is .218 of a foot; what will be the length of the middle ordinate of a sub-chord of 50 feet? Here,

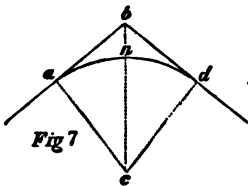
Sq. of 100 ft. :	Sq. of 50 ft. ::	Mid. Ord. of Chord. :	Mid. Ord. Sub-Chord approximately,
10000 :	2500 ::	.218 ft. :	.0545 ft.

And so of any other ordinate, always supposing the chord and sub-chord to be divided into the *same number of parts*.

## ARTICLE VI.

*Having given the angle a b d, fig. 7, it is required to find the point a or d, at which to commence a curve of given radius.*

*Rule.*—Subtract half the angle  $a b d$  from  $90^\circ$ ; the remainder will be the angle  $b c a$ , or  $b c d$ . From the table of tangents take the natural tangent of  $b c a$ , and multiply it by the given radius; the product will be  $b a$ , or  $b d$ .



*Example.*—Let the angle  $a b d$  be  $120^\circ$ , how far from  $b$  must we begin, at  $a$  or  $d$ , to lay out a curve

$a n d$ , of 2865 feet radius?

Here, half of the angle  $a b d = 60^\circ$ , which taken from  $90^\circ$  leaves the angle  $b c a = 30^\circ$ . The natural tangent of  $30^\circ = .5773$ , which multiplied by the radius of 2865 feet, gives 1653.96 feet for  $b a$  or  $b d$ . (See Art. XII.)

## ARTICLE VII.

*Having given the angle  $a b d$ , fig. 7, and the distance from  $b$  to  $a$  or  $d$ , at one of which we wish to commence a curve, it is required to find what radius  $a c$  or  $c d$ , the curve must have, in order to unite with  $b a$  and  $b d$  tangentially at  $a$  and  $d$ .*

*Rule.*—Subtract the angle  $a b c$ , which is half the angle  $a b d$ , from  $90^\circ$ ; the remainder will be the angle  $b c a$ , or  $b c d$ . Then as nat. sine of  $b c a$ ,\* is to nat. sine of  $a b c$ ,† so is  $a b$  to  $a c$ , the radius required.

*Example.*—Let the angle  $a b d$  be  $120^\circ$ , and the distance  $b a$  or  $b d$  1654 feet; what will be the radius  $a c$  or  $c d$  of a circle that shall touch  $a$  and  $d$  tangentially.

Here the angle  $a b c =$  half the angle  $a b d$ , is  $60^\circ$ , which taken from  $90^\circ$ , leaves the angle  $b c a$ , or  $b c d = 30^\circ$ . Then as the nat. sine of  $b c a$  ( $30^\circ$ ) = .5000 is to nat. sine of  $a b c$ , ( $60^\circ$ ) = .8660, so is  $b a$  (1654 feet) to  $a c$ , (2865 feet,) the radius required.

## ARTICLE VIII.

*Having given the radius  $a c$ , fig. 7, of a curve, and the angle  $a b d$ , it is required to find the number of chords of 100 feet that will constitute the curve.*

*Rule.*—Subtract the angle  $a b d$  from  $180^\circ$ , and divide the remainder by the angle of curvature, or deflection of the curve. The quotient will be the required number of chords.

*Example.*—Let the angle  $a b d$  be  $120^\circ$ , and the radius  $a c$ , 2865 feet.

Here the angle  $a b d$ ,  $120^\circ$ , subtracted from  $180^\circ$ , leaves a remainder of  $60^\circ$ ; which, divided by  $2^\circ$ , the angle of deflection for a curve of 2865 feet, gives a quotient of 30; which is the required number of chords of 100 feet.

N. B.—Had the quotient contained a fraction of a chord, it would have indicated that we should have had to employ a sub-chord at the end of the curve; for instance, had the number of chords been  $30\frac{1}{2}$ , a sub-chord of 50 feet (very approximately) would have been necessary.

\* The angle opposite the given side,  $a b$ .

† The angle opposite the required side,  $a c$ .

## ARTICLE IX.

*How to proceed when the end of a curve does not correctly join the tangent.*

We sometimes find, in running out a curve for the number of chords determined by the Rule in the preceding Article, that instead of uniting as it should with the previously determined tangent  $d m$ , fig. 8, at  $o$ , it ends tangentially to a line *parallel* to said tangent, either *within* it, as at  $c$ ; or *beyond* it, as at  $b$ . Being first certain that no error has occurred in tracing out the curve, ascertain with the compass the bearing of the tangent  $a d$ , and, removing the compass to the end of the curve at  $c$  or  $b$ , (as the case may be,) run the line  $b o$  or  $c o$ , in the same course as  $a d$ , until it strikes the tangent  $d o m$ ; which may be ascertained by ranging two stakes placed on the tangent.

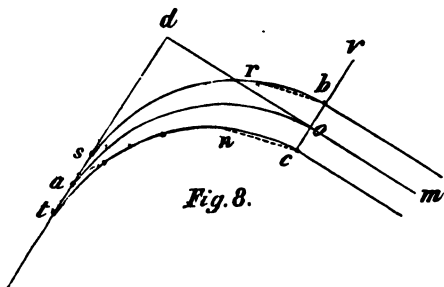


Fig. 8.

Then measure  $b o$ , or  $c o$ , (as the case may be,) and if the curve fall *within* the tangent  $o m$ , as at  $c$ , measure *forwards* from  $t$  towards  $d$ , the distance  $t a$ , equal to  $c o$ ; or if the curve fall *beyond* the tangent, as at  $b$ , measure *backwards* from  $s$ , the distance  $s a$  equal to  $b o$ . Then the curve retraced from  $a$ , will terminate tangentially in  $d m$  at  $o$ .

N. B.—The direction of  $c o$  or  $b o$  may be ascertained without a compass, and better, thus: Multiply the *tangential* angle of the curve by *twice* the number of chords run, *less one*; subtract the product from  $180^\circ$ , and sighting back one chord to  $n$  or  $r$ , lay off the angle  $n c b$ , or  $r b v$ , equal to the remainder. For example, if the tangential angle be  $10^\circ$ , and from  $t$  to  $c$  be 4 chords, then 7 times  $10^\circ$  taken

from  $180^\circ$  leaves the angle  $n c b$ , or  $r b v = 110^\circ$ . When the product exceeds  $180^\circ$ , it must be subtracted from  $360^\circ$ , for the angle  $n c b$ , or  $r b v$ .\*

This case occurs whenever an error has been made in measuring the distance from  $d$  to  $a$ . If  $d a$  be made too short, the curve  $s b$  is the result; and if too long, the curve  $t c$ .

If the error is small, it may be divided equally among the chords by measure, without retracing the curve with an instrument. This method may be employed with perfect security so long as the error does not exceed 1 foot to every chord of 100 feet; and it will never be so great if moderate care be taken.

Thus, if the curve be 20 chords long, and the error 20 feet, the last stake may be moved 20 feet, the next 19, the next 18, &c., as nearly at right angles to the curve as can be judged by the eye.

The same ordinates that would have been used had the curve been correct, will answer for the one so adjusted, without perceptible difference. For other cases, see Art. X.

## ARTICLE X.

Again, it may happen that the error is not caused by a mismeasurement of the distance  $a e$ , figs. 9 and 10, as in the last case; but by mistake in obtaining the angle  $a e f$ .

Fig. 9.

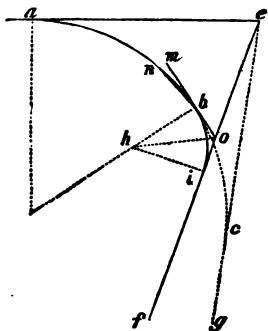
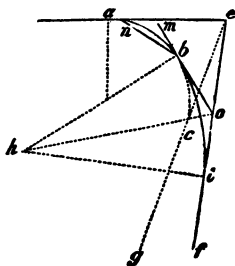


Fig. 10.



If  $a e f$ , fig. 9, be measured in excess, as  $a e g$ , then the

\* In both cases the angle is measured *outwardly* from the curve; but when the curve falls beyond the tangent, as at  $b$ , then  $b v$  must be continued inwardly as  $b o$ .

curve  $a b c$ , calculated for the incorrect angle  $a e g$ , will be found to fall *beyond* the true tangent  $e f$ , as at  $c$ ; and the tangents  $e g$  and  $e f$  not being parallel, the curve cannot be adjusted by either of the methods given in the preceding Article, unless the error be within about 1 foot to each 100 feet length of the curve; in which case, (supposing no other error to exist,) either of those methods may be employed, with sufficient accuracy for practice.

Also, if  $a e f$ , fig. 10, be measured too small, as  $a e g$ , then the curve  $a b c$ , calculated for the incorrect angle  $a e g$ , will be found to fall *within* the true tangent  $e f$ , as at  $c$ ; when so, the remarks contained in the preceding sentence are equally applicable here. If the error be within 1 foot to 100 feet length of curve, it may be equally divided among the chords. But if greater, we must either remeasure the angle  $a e f$  correctly, and go over the whole work again, or resort to some other mode of obviating the difficulty. The angle  $a e f$  may be difficult of access; or the curve may be so long that to retrace it would be a work of much labor. We may then adopt the method of *compound curves*, (see Art. XIII.,) by which much trouble will be avoided, and a considerable portion of the first part of the curve be allowed to remain as it is.

Thus, whether the curve  $a b c$  fall beyond the true tangent  $e f$ , as in fig. 9, or inside of it, as in fig. 10, place the instrument at  $b$ , figs. 9 and 10, (the point at which the change of radius is to take place,) and sighting back one chord to  $n$ , lay off the tangential angle  $n b m$  of the curve  $a b c$ , and observe where the tangent  $m b$  continued, strikes  $e f$ , as at  $o$ . Measure both  $b o$ , and the angle  $b o f$ . Half the angle  $b o f$  taken from  $90^\circ$ , gives the angle  $b h o$ ; then say,

As the  $\left\{ \begin{array}{l} \text{Nat. Sine of angle } b h o \text{ op-} \\ \text{posite the given side, } b o, \end{array} \right\}$  is to  $\left\{ \begin{array}{l} \text{Nat. Sine of angle } b o f \\ \text{opposite the required} \\ \text{side } b h, \end{array} \right\}$

So is The given side  $b o$ , to The required side, or new radius  $b h$ .

Ascertain from the table, or by calculation, the angle of deflection, and the tangential angle corresponding to this new radius  $b h$ ; and the new curve commencing at  $b$  will terminate tangentially to  $e f$  at  $i$ , as far from  $o$  as  $o$  is from  $b$ .

For the mode of uniting two curves of different radii, so as to form a *compound curve*, see Article XIII.

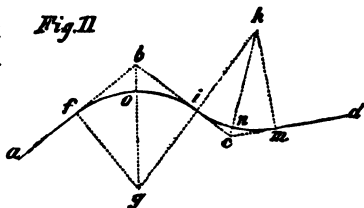
It will be observed, that when the first curve,  $a b c$ , fig. 10, falls *inside* the tangent  $e f$ , the new curve must be of *greater* radius; and when *beyond* fig. 9, of a *less* one.

## ARTICLE XI.

*Having given the angles  $a b c$  and  $b c d$ , fig. 11, and the distance  $b c$ , it is required to find the greatest radius,  $g i$ , or  $h i$ , that can be employed in a REVERSE curve, (see Article XIV)  $f o i n m$ , for uniting  $a b$  to  $c d$ .*

**Rule.**—Half the angle  $a b c$  taken from  $90^\circ$ , leaves the angle  $b g i$ ; and half the angle  $b c d$  taken from  $90^\circ$ , leaves the angle  $i h c$ .

From the table of tangents take the natural tangent ( $b i$ ) of the angle  $b g i$ ; and that ( $i c$ ) of the angle  $i h c$ ; and add them together.



Then as the sum of these two nat. tangents is to the nat. tang. of  $b g i$ , so is  $b c$  to  $b i$ ; and  $b i$  taken from  $b c$ , gives  $i c$ .

Again, in the triangle  $b g i$ , as the nat. sine of the angle  $b g i$ , opposite the given side  $b i$ , just found, is to the nat. sine of the angle  $g b i$ , opposite the required side  $g i$ , so is  $b i$ , the given side, to  $g i$ , the required side or radius.

**Example.**—Let the angle  $a b c$  be  $71^\circ 40'$ , the angle  $b c d$   $129^\circ 15'$ , and the distance  $b c$  950 feet. What is the length of radius  $h i$  or  $g i$ , of the easiest reverse curve that can be traced for uniting  $a b$  to  $c d$ ?

Here, half the angle  $a b c$  ( $35^\circ 50'$ ) taken from  $90^\circ$ , leaves the angle  $b g i$   $54^\circ 10'$ ; and half the angle  $b c d$  ( $64^\circ 37\frac{1}{2}'$ ) taken from  $90^\circ$ , leaves the angle  $i h c$   $= 25^\circ 22\frac{1}{2}'$ .

From the table of tangents, we have nat. tang. of  $b g i$  ( $54^\circ 10'$ )  $= 1.3848$ ; and nat. tang. of  $i h c$  ( $25^\circ 22\frac{1}{2}'$ )  $= .4743$ ; their sum being 1.8591.



Then as

$$\left. \begin{array}{l} \text{Sum of Tang's.} \\ 1.8591 \end{array} \right\} \text{ is to } \left\{ \begin{array}{l} \text{Tang. of} \\ 54^{\circ} 10' \\ 1.3848, \end{array} \right\} \text{ so is } \left\{ \begin{array}{l} b c \\ 950 \text{ ft.,} \end{array} \right\} \text{ to } \left\{ \begin{array}{l} b i \\ 707.63 \text{ ft.,} \end{array} \right\}$$

and  $b i$ , 707.63 feet, taken from  $b c$ , 950 feet, leaves  $i c$  242.37 feet.

Again, as the

$$\left. \begin{array}{l} \text{Nat. Sine} \\ \text{of angle} \\ b g i \\ .8107 \end{array} \right\} \text{ is to } \left\{ \begin{array}{l} \text{Nat. sine of} \\ \text{Angle } g b i \\ .5854, \end{array} \right\} \text{ so is } \left\{ \begin{array}{l} b i \\ 707.63 \\ \text{feet} \end{array} \right\} \text{ to } \left\{ \begin{array}{l} g i \text{ or } h i, \text{ the} \\ \text{required ra-} \\ \text{dius, } 510.97 \\ \text{feet.} \end{array} \right\}$$

## ARTICLE XII.

To obtain the angle  $d b e$ , formed by two tangents,  $d b$ , and  $b e$ , when the point  $b$  is inaccessible. Figs. 12, 13, 14, and 15.

This is of frequent occurrence.

CASE 1. When the included figure, fig. 12, has but *three* sides.

*Rule.*—Subtract the angle  $a d e$  from  $180^{\circ}$  for the angle  $b d e$ ; and subtract the angle  $d e c$  from  $180^{\circ}$ , for the angle  $d e b$ . Add together  $b d e$  and  $d e b$ , and subtract their sum from  $180^{\circ}$ , for the angle  $d b e$ .

Fig. 12.

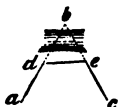


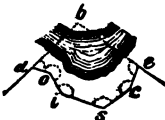
Fig. 13.



Fig. 14.



Fig. 15.



CASE 2. When the included figure,  $d b e f$ , figs. 13 and 14, has *four* sides.

*Rule.*—Subtract the sum of the three *internal* angles of the figure marked by dotted segments of circle, from  $360^{\circ}$ , for the angle  $d b e$ .

CASE 3. When the included figure, 15, has *more than four sides*.

**Rule.**—Add together all the *internal* angles, marked by dotted segments of circles; and subtract their sum from twice as many right angles as the figure has sides, less four, for the angle  $d b e$ .

**Example.**—Let the angles denoted by the dotted segments at the different letters be as follows: That at  $d$ ,  $70^\circ$ ; at  $e$ ,  $220^\circ$ ; at  $i$ ,  $150^\circ$ ; at  $s$ ,  $110^\circ$ ; at  $c$ ,  $160^\circ$ ; at  $e$ ,  $100^\circ$ . The sum of these is  $810^\circ$ . The figure has 7 sides; and twice 7, less  $4 = 10$ ; and 10 right angles  $= 900^\circ$ ; from which the sum of the designated internal angles ( $810^\circ$ ) being subtracted, leaves  $90^\circ$ , for the angle  $d b e$ .

N. B.—When the angle  $d b e$  has to be deduced from a figure of many sides, as fig. 15, the errors spoken of in Articles IX. and X. are apt to occur, unless the several sides and the angles  $o$ ,  $i$ ,  $s$ , &c., be measured with much care. For tracing curves with any accuracy and satisfaction, the instrument should be divided at least into minutes; as before remarked, the transit instrument is the best for the purpose. With moderate care in the preparatory measurement of the sides and angles, errors will seldom occur that may not be adjusted with all the accuracy required in practice, by the very simple method of dividing them equally among the chords, as explained in Articles IX. and X.

### ARTICLE XIII.

*To pass from one curve,  $a m b$ , fig. 16, to another,  $b n c$ , of different radius, but running in the same direction, constituting a COMPOUND curve.*

**Rule.**—Placing the instrument at  $b$ , sight back to the other end of the 100 feet chord at  $a$ ; and lay off the *tangential* angle  $a b d$ , of the curve  $a m b$ ; then from the common tangent  $d b e$ , lay off the *tangential* angle  $e b c$ , of the curve  $b n c$ , making at the same time the chord  $b c$  equal to 100 feet.

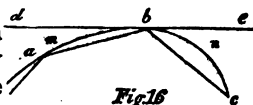


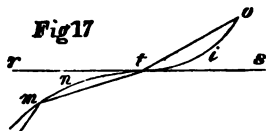
Fig. 16

N. B.—If running the curve by eye, use the *tangential distances* instead of the angles.

## ARTICLE XIV.

*To pass from one curve,  $m n t$ , fig. 17, to another,  $t i o$ , of either the same, or of a different radius, but running in an opposite direction; constituting a REVERSE curve.*

*Rule.*—Placing the instrument at  $t$ , sight back to the other end of the 100 feet chord at  $m$ , and lay off the tangential angle  $m t r$ , of the curve  $m n t$ ; then from the common tangent  $r t s$ , lay off the tangential angle  $s t o$ , of the curve  $t i o$ ; making at the same time the chord  $t o$ ,



equal to 100 feet.

N. B.—If running the curve by eye, use the tangential distances instead of the angles.

## ARTICLE XV.

## RADII.

*To find the radius corresponding to any given angle of deflection; and to equal chords of any given length.*

*Rule 1.*—Subtract the angle of deflection from  $180^\circ$ , then say, as nat. sine of angle of deflection, is to nat. sine of half the remainder, so is the given chord to the radius required.

*Example.*—Let the angle of deflection be  $2^\circ$ , and the chord 100 feet, required the radius.

Here  $2^\circ$  subtracted from  $180^\circ$ , leaves  $178^\circ$ , the half of which is  $89^\circ$ , and as

$$\begin{array}{ccccccc} \text{Nat. Sine of } 2^\circ & : & \text{Nat. Sine of } 89^\circ & :: & \text{Chord} & : & \text{Radius} \\ .034899 & : & .999848 & :: & 100 \text{ feet} & : & 2865 \text{ feet.} \end{array}$$

*Rule 2.*—The radius for 100 feet chords may be found approximately, by dividing 5730 by the deflection angle.

This rule is very close for radii of not less than 500 feet. For 500 feet it gives eight-tenths of a foot too little, but is more approximate for larger radii.

*Example.*—What is the radius to a deflection angle of  $2^\circ$ , the chords being 100 feet long?

Here, 5730 divided by 2, gives 2865 feet, the radius required.

## ARTICLE XVI.

### TANGENTIAL AND DEFLECTION ANGLES.

*To find either the Tangential or Deflection Angle corresponding to any given radius, and to equal chords of any given length.*

*Rule 1.*—Divide *half* the chord by the radius; the quotient will be the natural sine of the *tangential* angle. Therefore, the angle corresponding to this sine, in the table of natural sines, will be the tangential angle required; and the tangential angle multiplied by 2 will give the deflection angle.

*Example.*—Let the radius be 2865 feet, and the chord 100 feet; what will be the tangential and deflection angles?

Here, half the chord, (50 feet,) divided by the radius, (2865 feet,) gives  $\cdot 01745$ ; and the tangential angle in the table corresponding to the natural sine  $\cdot 01745$  is  $1^\circ$ , twice which is  $2^\circ$ , the deflection angle required.

*Rule 2.*—The deflection angle for 100 feet chords may be found approximately by dividing 5730 by the radius. This is very close for curves of over 500 feet radius. For 500 feet it gives about one minute too little.

*Example.*—What is the deflection angle for a radius of 2865 feet, the chords being 100 each?

Here, 5730 divided by the radius 2865, gives  $2^\circ$ , the deflection angle required.

## ARTICLE XVII.

## DEFLECTION DISTANCES.

*To find the Deflection Distance (exactly) for any given radius, when the chords are 100 feet long.*

*Rule.*—Divide the constant number 10000 by the radius in feet; the quotient will be the deflection angle required.\*

*Example.*—What is the deflection distance to a radius of 5730 feet, the chords being 100 feet long?

Here, 10000 divided by 5730 radius, gives 1.745 feet, the deflection distance required.

*To find the Deflection Distance for any given radius, and for equal chords of any given length.*

*Rule.*—Divide half the given chord by radius, the quotient will be the natural sine of one-half the deflection angle; and double this natural sine, multiplied by the chord, will give the deflection distance required. By this rule our table was prepared.

*Example.*—As before, what is the deflection distance to a radius of 5730 feet, the chords being 100 feet long?

Here, half the chord, (50 feet,) divided by radius, (5730 feet,) gives .008727, which is the natural sine of half the deflection angle. Now .008727, multiplied by 2, gives .017454, which, multiplied by the chord, (100 feet,) gives 1.745 feet, the required deflection distance, the same as in the preceding example.

## ARTICLE XVIII.

## TANGENTIAL DISTANCES.

*To find the Tangential Distance corresponding to any given radius, and to equal chords of any given length.*

*Rule.*—First find the tangential angle by Article XVI., and take from the table of natural sines, that correspond-

\* Because the deflection distance to a radius of 10000 feet, with chords of 100 feet, is 1 foot; and the deflection distances for other radii increase *inversely* as the radii.

ing to one-half of the *tangential* angle. Then multiply *double* this sine by the given chord, for the *tangential* distance. By this rule our table was prepared.

*Example.*—Let the radius be 2865 feet, and the chords 100 feet each; what will be the *tangential* distance?

Here we find, by Article XVI., the *tangential* angle  $1^\circ$  for a radius of 2865 feet.

The natural sine corresponding to 30 minutes, or one-half of this *tangential* angle, is, by the table of sines, .008727; the double of which is .017454, which, multiplied by the chord, or 100 feet, gives 1.745 feet for the *tangential* distance required.

## ARTICLE XIX.

### ORDINATES.

*To find the Middle Ordinate to any given radius, and to any given chord.*

*Rule 1.*—From the square of the radius subtract the square of *half* the chord; and take the square root of the remainder from the radius, for the middle ordinate.

*Example.*—What is the length of the middle ordinate *d e*, fig. 18, the radius *c a* being 819 feet, and the chord *a b* 100 feet?

Here, the square of *c a* (819) is 670761, and the square of *a e* (50) is 2500; which, being subtracted from the former, leaves 668261; the square root of which is *e c*, 817.472; which, taken from the radius 819, leaves 1.528 feet, the required middle ordinate, *d e*.

*Rule 2.*—Subtract the tabular cosine of the *tangential* angle from 1, and multiply the remainder by the radius.

*Example.*—Same as foregoing, namely, radius 819 feet, angle of deflection  $7^\circ$ , to chords of 100 feet. What will be the length of the middle ordinate?

Here, tabular cosine of  $3\frac{1}{2}^\circ$  (the *tangential* angle) is .998135; which, subtracted from 1, leaves .001865; which, multiplied by 819, the radius, gives 1.527, the middle ordinate required.

## ARTICLE XX.

*Having given the Middle Ordinate  $d e$ , fig. 18, it is required to find any other one, as  $i n$ .*

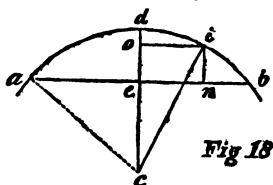


Fig 18

**Rule 1.**—Subtract the middle ordinate  $d e$ , from the radius  $d c$ , the remainder will be  $e c$ : then from the square of the radius  $c i$ , subtract the square of the distance  $o i$ , which the required ordinate  $i n$  is from the middle

ordinate  $d e$ , and extract the square root of the remainder. This square root will be  $o c$ . From this square root  $o c$ , subtract  $e c$ ; the remainder will be  $o e$ , which is equal to  $i n$ , the required ordinate.

**Example.**—The middle ordinate  $d e$ , of a 100 feet chord  $b a$ , to a radius of 819, being 1.528 feet, it is required to find the length of the ordinate  $i n$ , 20 feet from the middle one.

Here, the middle ordinate  $d e$ , 1.528, subtracted from the radius 819, leaves  $e c$ , 817.472. The square of the radius is 670761; and the square of 20 (the distance of the required ordinate from the middle one) is 400; which taken from 670761, leaves 670361; the square root of which is 818.756, or  $o c$ ; from which take  $e c$ , or 817.472, and the remainder, 1.284, will be  $o e$ , which is equal to  $i n$ , the required ordinate.

**Rule 2.**—Multiply the ordinates of a  $1^{\circ}$  curve by the deflection angle of the curve whose ordinates are required, (chords being 100 feet.) This is a sufficiently close approximation for curves of not less than 500 feet radius; and for placing ordinates *for guiding the excavations and embankments*, it is close enough for the smallest curves in our table.

## TABLE OF RADII, &amp;c.—CHORD 100 FEET.

*The Tangential Angle is always one-half of the Angle of Deflection.*

Angle of Deflection.	Radius in feet.	Deflection distance in feet.	Tangential distance in feet.	Angle of Deflection.	Radius in feet.	Deflection distance in feet.	Tangential distance in feet.
°				°			
1	343800	·029	·014	44	7814	1·279	·639
2	171900	·058	·029	45	7640	1·308	·654
3	114600	·087	·043	46	7474	1·337	·668
4	85950	·116	·058	47	7315	1·366	·683
5	68760	·145	·072	48	7162	1·395	·697
6	57800	·174	·087	49	7016	1·424	·712
7	49116	·203	·101	50	6876	1·453	·726
8	42975	·232	·116	51	6741	1·482	·741
9	38200	·262	·131	52	6611	1·511	·755
10	34380	·291	·145	53	6487	1·540	·770
11	31256	·320	·160	54	6367	1·569	·784
12	28650	·349	·174	55	6251	1·598	·799
13	26446	·378	·189	56	6139	1·627	·813
14	24558	·407	·203	57	6032	1·656	·828
15	22920	·436	·218	58	5928	1·685	·842
16	21487	·465	·232	59	5827	1·715	·857
17	20224	·494	·247	i	5730	1·745	·872
18	19100	·523	·261	2	5545	1·802	·901
19	18094	·552	·276	4	5372	1·860	·930
20	17190	·581	·290	6	5209	1·918	·959
21	16372	·610	·305	8	5056	1·976	·988
22	15628	·639	·319	10	4912	2·036	1·018
23	14948	·668	·334	12	4775	2·094	1·047
24	14325	·697	·348	14	4646	2·152	1·076
25	13752	·727	·363	16	4524	2·210	1·105
26	13223	·756	·378	18	4408	2·268	1·134
27	12733	·785	·392	20	4298	2·326	1·163
28	12279	·814	·407	22	4193	2·384	1·192
29	11856	·843	·421	24	4093	2·443	1·221
30	11460	·872	·436	26	3998	2·501	1·250
31	11090	·900	·450	28	3907	2·559	1·279
32	10744	·930	·465	30	3820	2·617	1·308
33	10419	·959	·479	32	3737	2·676	1·338
34	10112	·988	·494	34	3657	2·734	1·367
35	9823	1·017	·508	36	3581	2·793	1·396
36	9550	1·046	·523	38	3508	2·851	1·425
37	9292	1·075	·537	40	3438	2·908	1·454
38	9047	1·104	·552	42	3370	2·967	1·483
39	8815	1·133	·566	44	3306	3·025	1·512
40	8595	1·162	·581	46	3243	3·083	1·541
41	8385	1·191	·595	48	3183	3·141	1·570
42	8186	1·221	·610	50	3126	3·199	1·599
43	7995	1·250	·625	52	3069	3·258	1·629



## TABLE OF RADII, &amp;c.—CHORD 100 FEET.

CONTINUED.

*The Tangential Angle is always one-half of the Angle of Deflection.*

Angle of Deflection.	Radius in feet.	Deflection distance in feet.	Tangential distance in feet.	Angle of Deflection.	Radius in feet.	Deflection distance in feet.	Tangential distance in feet.
1° 54'	3016	3·316	1·658	3° 20'	1719	5·817	2·908
56	2964	3·374	1·687	22	1702	5·875	2·937
58	2914	3·432	1·716	24	1685	5·933	2·966
1° 20'	2865	3·490	1·745	26	1669	5·992	2·996
2	2818	3·548	1·774	28	1653	6·050	3·025
4	2772	3·606	1·803	30	1637	6·108	3·054
6	2729	3·665	1·832	32	1621	6·166	3·083
8	2686	3·723	1·861	34	1606	6·224	3·112
10	2644	3·781	1·890	36	1591	6·282	3·141
12	2604	3·839	1·919	38	1577	6·340	3·170
14	2566	3·897	1·948	40	1563	6·398	3·199
16	2528	3·956	1·978	42	1549	6·456	3·228
18	2491	4·014	2·007	44	1534	6·515	3·257
20	2456	4·072	2·036	46	1521	6·574	3·287
22	2421	4·130	2·065	48	1508	6·632	3·316
24	2387	4·188	2·094	50	1495	6·690	3·345
26	2355	4·246	2·123	52	1482	6·748	3·374
28	2323	4·305	2·152	54	1469	6·806	3·403
30	2292	4·363	2·182	56	1457	6·864	3·432
32	2262	4·421	2·210	58	1445	6·922	3·461
34	2232	4·479	2·239	4° 5'	1433	6·980	3·490
36	2204	4·538	2·269	5	1403	7·125	3·562
38	2176	4·596	2·298	10	1375	7·270	3·635
40	2149	4·653	2·326	15	1348	7·416	3·708
42	2122	4·712	2·356	20	1322	7·563	3·781
44	2096	4·770	2·385	25	1298	7·708	3·854
46	2071	4·828	2·414	30	1274	7·853	3·927
48	2046	4·886	2·443	35	1251	7·998	3·999
50	2023	4·944	2·472	40	1228	8·143	4·071
52	1999	5·002	2·501	45	1207	8·289	4·145
54	1976	5·060	2·530	50	1185	8·432	4·216
56	1953	5·118	2·559	55	1166	8·577	4·288
58	1932	5·176	2·588	5° 5'	1146	8·722	4·361
1° 20'	1910	5·235	2·618	5	1127	8·869	4·434
2	1889	5·293	2·646	10	1109	9·014	4·507
4	1868	5·351	2·675	15	1092	9·159	4·579
6	1848	5·409	2·704	20	1074	9·304	4·652
8	1828	5·468	2·734	25	1058	9·449	4·724
10	1810	5·526	2·763	30	1042	9·595	4·798
12	1790	5·584	2·792	35	1026	9·740	4·870
14	1772	5·642	2·821	40	1011	9·885	4·942
16	1754	5·700	2·850	45	996·8	10·03	5·015
18	1736	5·758	2·879	50	982·7	10·18	5·090

## TABLE OF RADII, &amp;c.—CHORD 100 FEET.

CONTINUED.

*The Tangential Angle is always one-half of the Angle of Deflection.*

Angle of Deflection.	Radius in feet.	Deflection distance in feet.	Tangential distance in feet.	Angle of Deflection.	Radius in feet.	Deflection distance in feet.	Tangential distance in feet.
5 55	969.0	10.32	5.160	12 30	459.3	21.79	10.90
6	955.4	10.47	5.235	45	450.3	22.21	11.12
5	947.5	10.62	5.310	13	441.7	22.64	11.34
10	939.7	10.76	5.380	15	433.4	23.07	11.56
15	917.0	10.90	5.450	30	425.5	23.51	11.77
20	905.0	11.04	5.520	45	417.7	23.94	11.99
25	893.5	11.20	5.600	14	410.8	24.37	12.21
30	882.0	11.34	5.670	15	403.1	24.81	12.43
35	870.7	11.48	5.740	30	396.2	25.24	12.65
40	859.5	11.63	5.815	45	389.6	25.67	12.86
45	849.3	11.78	5.890	15	383.1	26.11	13.08
50	838.9	11.92	5.960	15	376.9	26.52	13.30
55	828.9	12.06	6.030	30	370.8	26.94	13.52
7	819.0	12.21	6.105	45	365.0	27.37	13.73
5	813.3	12.36	6.180	16	359.3	27.83	13.95
10	807.4	12.50	6.250	30	348.4	28.70	14.38
15	790.8	12.64	6.320	17	338.3	29.56	14.82
20	781.9	12.79	6.395	30	328.7	30.43	15.25
25	773.2	12.94	6.470	18	319.6	31.29	15.69
30	764.5	13.08	6.540	30	311.0	32.15	16.12
35	756.1	13.22	6.610	19	302.9	33.01	16.56
40	748.0	13.37	6.685	30	295.3	33.87	16.99
45	739.9	13.51	6.755	20	287.9	34.73	17.43
50	732.0	13.66	6.830	21	274.4	36.44	18.30
55	724.3	13.80	6.900	22	262.0	38.15	19.17
8	716.8	13.95	6.975	23	250.8	39.87	20.02
15	695.1	14.88	7.190	24	240.5	41.58	20.91
30	674.6	14.81	7.405	25	231.0	43.28	21.77
45	655.5	15.25	7.625	26	222.3	44.98	22.64
9	637.3	15.68	7.840	27	214.2	46.68	23.51
15	620.2	16.12	8.060	28	206.7	48.38	24.37
30	603.8	16.55	8.275	29	199.7	50.07	25.24
45	588.4	16.99	8.495	30	193.2	51.76	26.11
10	573.7	17.43	8.715	31	187.1	53.45	26.97
15	559.7	17.87	8.935	32	181.4	55.13	27.83
30	546.4	18.30	9.150	33	176.0	56.80	28.70
45	533.8	18.73	9.365	34	171.0	58.47	29.56
11	521.7	19.17	9.585	35	166.3	60.14	30.42
15	510.1	19.61	9.805	36	161.8	61.80	31.29
30	499.1	20.05	10.03	37	157.6	63.46	32.15
45	488.5	20.50	10.25	38	153.6	65.11	33.01
12	478.3	20.94	10.47	39	149.8	66.76	33.87
15	468.7	21.36	10.69	40	146.2	68.40	34.73

## TABLE OF ORDINATES.

*Ordinates five feet apart.—Chord one hundred feet.*

Distances of the Ordinates from the end of the 100 feet Chord.										
Angle of Def'n.	Middle, 50 feet.	45 feet.	40 feet.	35 feet.	30 feet.	25 feet.	20 feet.	15 feet.	10 feet.	5 feet.
0										
2	·007	·007	·007	·006	·006	·005	·003	·003	·002	·001
4	·014	·014	·014	·013	·012	·010	·008	·008	·005	·003
6	·021	·021	·021	·020	·019	·016	·013	·011	·008	·004
8	·029	·029	·028	·026	·024	·022	·018	·015	·010	·005
10	·036	·036	·035	·033	·031	·027	·023	·019	·013	·007
12	·043	·043	·041	·038	·037	·033	·028	·022	·015	·008
14	·050	·050	·048	·044	·043	·038	·032	·026	·017	·010
16	·058	·058	·056	·052	·049	·044	·037	·030	·020	·011
18	·065	·065	·063	·059	·055	·050	·042	·033	·023	·013
20	·073	·072	·070	·066	·061	·055	·047	·037	·026	·014
22	·080	·079	·076	·071	·067	·060	·051	·041	·029	·015
24	·087	·086	·083	·077	·074	·066	·056	·045	·031	·017
26	·094	·093	·090	·084	·080	·071	·060	·048	·034	·018
28	·102	·101	·098	·092	·086	·077	·065	·052	·036	·019
30	·109	·108	·105	·099	·092	·082	·070	·055	·039	·020
32	·116	·115	·112	·106	·098	·088	·075	·058	·042	·022
34	·123	·122	·118	·111	·104	·094	·079	·062	·044	·023
36	·131	·130	·126	·119	·110	·099	·084	·066	·047	·024
38	·138	·137	·133	·126	·116	·105	·089	·070	·049	·025
40	·145	·144	·140	·133	·123	·110	·093	·074	·052	·027
42	·152	·150	·146	·138	·128	·115	·098	·077	·055	·028
44	·160	·158	·153	·145	·135	·121	·103	·081	·057	·030
46	·167	·165	·160	·152	·141	·126	·107	·085	·060	·032
48	·174	·172	·167	·158	·147	·132	·112	·088	·062	·033
50	·182	·180	·175	·166	·153	·138	·117	·092	·065	·034
52	·189	·187	·181	·171	·159	·143	·122	·095	·068	·035
54	·196	·194	·188	·178	·165	·148	·126	·099	·070	·036
56	·204	·202	·195	·185	·171	·154	·131	·103	·078	·038
58	·211	·209	·202	·192	·177	·159	·136	·107	·075	·039
i	·218	·216	·209	·198	·183	·164	·140	·111	·078	·041
2	·225	·223	·215	·204	·189	·169	·145	·114	·081	·042
4	·233	·231	·223	·211	·196	·175	·150	·118	·083	·043
6	·240	·238	·230	·217	·202	·180	·155	·121	·086	·045
8	·247	·245	·237	·224	·208	·186	·159	·125	·088	·046
10	·254	·252	·244	·231	·214	·191	·163	·130	·091	·048
12	·262	·260	·252	·237	·220	·196	·168	·133	·094	·049
14	·269	·267	·258	·244	·226	·202	·173	·136	·096	·050
16	·276	·274	·265	·251	·232	·207	·177	·140	·099	·052
18	·284	·282	·273	·257	·238	·213	·182	·144	·101	·053
20	·291	·288	·279	·264	·244	·218	·187	·148	·104	·055

## TABLE OF ORDINATES—CONTINUED.

*Ordinates five feet apart.—Chord one hundred feet.*

Distances of the Ordinates from the end of the 100 feet Chord.										
Angle of Def'n.	Middle, 50 feet.	45 feet.	40 feet.	35 feet.	30 feet.	25 feet.	20 feet.	15 feet.	10 feet.	5 feet.
0										
1	22	·298	·295	·285	·270	·250	·224	·192	·151	·107
	24	·306	·303	·293	·277	·256	·229	·197	·155	·109
	26	·313	·310	·300	·284	·263	·235	·201	·159	·112
	28	·320	·317	·307	·291	·269	·240	·206	·163	·114
	30	·327	·324	·314	·297	·275	·246	·210	·167	·117
	32	·334	·331	·321	·304	·281	·251	·215	·171	·120
	34	·341	·338	·328	·310	·287	·257	·219	·174	·122
	36	·349	·345	·335	·317	·293	·262	·224	·178	·125
	38	·356	·353	·342	·323	·299	·268	·228	·182	·127
	40	·364	·360	·349	·330	·305	·273	·233	·185	·130
	42	·371	·367	·356	·337	·312	·278	·238	·189	·133
	44	·378	·374	·363	·343	·318	·284	·242	·192	·135
	46	·385	·382	·370	·350	·324	·289	·247	·196	·138
	48	·393	·389	·377	·356	·330	·295	·251	·200	·141
	50	·400	·396	·384	·364	·336	·300	·256	·204	·144
	52	·407	·403	·391	·370	·342	·305	·261	·208	·147
	54	·414	·410	·398	·376	·348	·311	·265	·211	·149
	56	·422	·418	·405	·383	·354	·316	·270	·215	·152
0	58	·429	·425	·412	·389	·360	·322	·275	·219	·154
2		·436	·432	·419	·397	·366	·327	·280	·222	·157
	2	·443	·439	·426	·402	·373	·332	·284	·226	·160
	4	·451	·446	·433	·409	·379	·338	·289	·230	·162
	6	·458	·454	·440	·416	·385	·343	·293	·234	·165
	8	·465	·461	·447	·425	·391	·349	·298	·237	·167
	10	·473	·468	·454	·430	·397	·355	·303	·241	·170
	12	·480	·475	·461	·437	·403	·360	·308	·245	·173
	14	·487	·482	·468	·443	·409	·366	·312	·248	·175
	16	·495	·490	·475	·450	·415	·371	·317	·252	·178
	18	·502	·497	·482	·456	·421	·377	·321	·256	·180
	20	·509	·504	·489	·463	·428	·382	·326	·260	·183
	22	·516	·511	·496	·470	·434	·387	·330	·264	·186
	24	·523	·518	·503	·476	·440	·393	·334	·267	·188
	26	·531	·526	·510	·483	·446	·398	·338	·271	·191
	28	·538	·533	·517	·489	·452	·404	·346	·275	·194
	30	·545	·540	·524	·496	·458	·409	·350	·278	·196
	32	·552	·547	·531	·503	·465	·415	·355	·282	·199
	34	·560	·554	·538	·509	·471	·420	·359	·285	·201
	36	·567	·562	·545	·516	·477	·425	·364	·289	·204
	38	·574	·569	·552	·522	·483	·431	·368	·293	·206
	40	·582	·576	·559	·529	·489	·436	·373	·297	·209

## TABLE OF ORDINATES—CONTINUED.

*Ordinates five feet apart.—Chord one hundred feet.*

Distances of the Ordinates from the end of the 100 feet Chord.										
Angle of Def'n.	Middle, 50 feet.	45 feet.	40 feet.	35 feet.	30 feet.	25 feet.	20 feet.	15 feet.	10 feet.	5 feet.
0										
2	42	·589	·588	·566	·536	·495	·441	·378	·301	·212
	44	·596	·590	·573	·542	·501	·447	·382	·304	·214
	46	·603	·598	·580	·549	·507	·452	·387	·308	·217
	48	·611	·605	·587	·555	·513	·458	·391	·312	·219
	50	·618	·612	·594	·562	·519	·464	·396	·315	·222
	52	·625	·619	·601	·569	·526	·469	·401	·319	·225
	54	·632	·626	·608	·575	·532	·474	·405	·322	·227
	56	·640	·634	·615	·582	·538	·480	·410	·326	·230
0	58	·647	·641	·622	·588	·544	·485	·414	·330	·232
3		·654	·648	·629	·595	·550	·491	·419	·334	·235
	2	·661	·655	·636	·602	·556	·496	·424	·338	·238
	4	·669	·662	·643	·608	·562	·502	·428	·341	·240
	6	·676	·670	·650	·615	·568	·507	·433	·345	·243
	8	·683	·677	·657	·621	·574	·512	·438	·349	·246
	10	·691	·684	·664	·629	·581	·518	·443	·353	·249
	12	·698	·691	·671	·635	·587	·523	·448	·357	·251
	14	·706	·698	·678	·642	·593	·529	·452	·360	·254
	16	·713	·705	·685	·649	·599	·534	·457	·364	·257
	18	·720	·713	·692	·655	·605	·540	·462	·368	·259
	20	·727	·720	·699	·662	·611	·545	·466	·371	·262
	22	·734	·727	·706	·668	·617	·550	·471	·375	·264
	24	·742	·734	·713	·675	·623	·556	·475	·378	·267
	26	·749	·742	·720	·682	·629	·561	·480	·382	·270
	28	·756	·749	·727	·688	·635	·567	·485	·386	·272
	30	·764	·756	·734	·695	·642	·573	·489	·390	·275
	32	·771	·763	·741	·702	·648	·578	·494	·394	·278
	34	·779	·770	·748	·708	·654	·584	·498	·397	·280
	36	·786	·777	·755	·715	·660	·589	·503	·401	·283
	38	·793	·785	·762	·721	·666	·594	·508	·405	·285
	40	·800	·792	·769	·728	·673	·600	·512	·408	·288
	42	·807	·799	·776	·734	·679	·605	·517	·412	·291
	44	·814	·806	·783	·741	·685	·611	·521	·415	·293
	46	·822	·814	·790	·748	·691	·616	·526	·419	·296
	48	·829	·821	·797	·754	·697	·621	·531	·423	·298
	50	·836	·828	·804	·761	·703	·627	·536	·427	·301
	52	·843	·835	·811	·768	·709	·632	·541	·431	·304
	54	·850	·842	·818	·774	·715	·638	·545	·434	·306
	56	·858	·850	·825	·781	·721	·643	·550	·438	·309
9	58	·865	·857	·832	·787	·728	·648	·555	·442	·311
4		·873	·864	·839	·794	·734	·655	·560	·445	·314

## TABLE OF ORDINATES—CONTINUED.

*Ordinates five feet apart.—Chord one hundred feet.*

Distances of the Ordinates from the end of the 100 feet Chord.										
Angle of Def'n.	Middle, 50 feet.	45 feet.	40 feet.	35 feet.	30 feet.	25 feet.	20 feet.	15 feet.	10 feet.	5 feet.
0										
4 5	.891	.882	.856	.810	.749	.668	.571	.454	.320	.169
10	.909	.900	.874	.827	.764	.682	.582	.464	.327	.178
15	.927	.918	.891	.844	.780	.695	.594	.478	.334	.176
20	.945	.936	.909	.860	.795	.709	.606	.482	.340	.179
25	.963	.954	.926	.877	.810	.723	.617	.491	.347	.188
30	.981	.972	.944	.893	.825	.736	.629	.501	.354	.186
35	.999	.990	.961	.909	.840	.750	.640	.510	.360	.189
40	1.017	1.008	.979	.926	.855	.764	.652	.519	.367	.198
45	1.036	1.026	.996	.943	.871	.777	.664	.529	.373	.196
50	1.054	1.044	1.014	.959	.886	.791	.676	.538	.380	.199
55	1.072	1.062	1.031	.976	.901	.804	.687	.547	.386	.208
6 5	1.091	1.080	1.048	.993	.917	.818	.699	.557	.393	.207
5	1.109	1.098	1.065	1.009	.932	.831	.711	.566	.400	.210
10	1.127	1.116	1.083	1.026	.947	.845	.722	.576	.406	.214
15	1.146	1.134	1.100	1.042	.963	.859	.734	.585	.413	.217
20	1.164	1.152	1.118	1.058	.978	.872	.746	.594	.419	.220
25	1.182	1.170	1.135	1.075	.993	.886	.757	.603	.426	.224
30	1.200	1.188	1.153	1.092	1.009	.900	.769	.613	.432	.228
35	1.218	1.206	1.170	1.108	1.024	.913	.781	.622	.438	.231
40	1.236	1.224	1.188	1.124	1.039	.927	.792	.631	.445	.235
45	1.255	1.242	1.205	1.141	1.055	.941	.804	.640	.452	.238
50	1.273	1.260	1.223	1.157	1.070	.954	.816	.649	.458	.241
55	1.291	1.278	1.240	1.174	1.085	.967	.827	.658	.465	.245
6 6	1.309	1.296	1.258	1.191	1.100	.982	.839	.668	.472	.248
5	1.327	1.314	1.275	1.207	1.115	.995	.851	.677	.478	.251
10	1.345	1.332	1.293	1.224	1.130	1.009	.862	.686	.485	.255
15	1.364	1.350	1.310	1.240	1.146	1.023	.874	.696	.492	.259
20	1.382	1.368	1.328	1.256	1.161	1.036	.886	.705	.498	.262
25	1.400	1.386	1.345	1.273	1.176	1.050	.897	.714	.505	.266
30	1.419	1.404	1.362	1.290	1.192	1.064	.909	.724	.511	.269
35	1.437	1.422	1.379	1.306	1.207	1.077	.921	.733	.517	.272
40	1.455	1.440	1.397	1.323	1.222	1.091	.932	.742	.524	.276
45	1.473	1.458	1.415	1.339	1.238	1.105	.944	.752	.531	.280
50	1.491	1.476	1.432	1.355	1.253	1.118	.956	.761	.537	.283
55	1.509	1.494	1.450	1.372	1.268	1.132	.967	.770	.544	.287
6 7	1.528	1.512	1.467	1.389	1.284	1.146	.979	.779	.551	.290
5	1.546	1.530	1.484	1.405	1.299	1.159	.991	.788	.557	.293
10	1.564	1.548	1.502	1.422	1.314	1.173	1.002	.798	.564	.297
15	1.582	1.566	1.520	1.438	1.330	1.187	1.014	.807	.570	.301
20	1.600	1.584	1.537	1.454	1.345	1.200	1.026	.816	.576	.304

## TABLE OF ORDINATES—CONTINUED.

*Ordinates five feet apart.—Chord one hundred feet.*

Distances of the Ordinates from the end of the 100 feet Chord.										
Angle of Def'n.	Middle, 50 feet.	45 feet.	40 feet.	35 feet.	30 feet.	25 feet.	20 feet.	15 feet.	10 feet.	5 feet.
7° 25'	1.618	1.602	1.555	1.471	1.360	1.214	1.037	.825	.583	.308
30	1.637	1.620	1.572	1.488	1.375	1.228	1.048	.835	.590	.311
35	1.655	1.638	1.589	1.504	1.390	1.241	1.060	.844	.596	.314
40	1.673	1.656	1.607	1.521	1.405	1.255	1.071	.854	.603	.318
45	1.692	1.674	1.624	1.537	1.421	1.269	1.088	.863	.610	.321
50	1.710	1.692	1.641	1.553	1.436	1.282	1.095	.872	.616	.324
55	1.728	1.710	1.659	1.570	1.451	1.296	1.106	.881	.623	.328
8° 15'	1.746	1.728	1.677	1.587	1.467	1.310	1.118	.891	.629	.332
30	1.801	1.782	1.729	1.637	1.518	1.351	1.153	.918	.649	.342
45	1.855	1.836	1.782	1.687	1.559	1.392	1.188	.946	.669	.353
9° 45'	1.910	1.890	1.834	1.737	1.605	1.433	1.223	.974	.689	.363
15	1.965	1.944	1.886	1.787	1.651	1.474	1.258	1.002	.708	.373
30	2.019	1.998	1.939	1.837	1.696	1.515	1.293	1.030	.728	.384
45	2.074	2.052	1.991	1.887	1.742	1.556	1.328	1.057	.748	.394
10° 45'	2.128	2.106	2.044	1.937	1.788	1.597	1.363	1.085	.767	.405
15	2.183	2.161	2.096	1.987	1.834	1.637	1.398	1.114	.787	.415
30	2.238	2.215	2.148	2.037	1.880	1.678	1.433	1.142	.807	.425
45	2.292	2.269	2.201	2.087	1.926	1.719	1.468	1.170	.827	.436
11° 45'	2.347	2.323	2.254	2.136	1.972	1.761	1.503	1.198	.846	.446
15	2.401	2.377	2.306	2.186	2.018	1.802	1.538	1.226	.866	.457
30	2.456	2.432	2.359	2.236	2.064	1.843	1.574	1.254	.886	.467
45	2.511	2.486	2.411	2.286	2.110	1.884	1.609	1.282	.906	.478
12° 45'	2.566	2.540	2.464	2.336	2.156	1.926	1.644	1.310	.926	.488
15	2.620	2.594	2.516	2.386	2.203	1.967	1.680	1.339	.946	.499
30	2.675	2.649	2.569	2.436	2.249	2.008	1.715	1.367	.966	.509
45	2.730	2.703	2.621	2.485	2.295	2.049	1.750	1.395	.985	.520
13° 45'	2.785	2.757	2.674	2.535	2.341	2.091	1.785	1.423	1.005	.530
15	2.839	2.811	2.726	2.585	2.387	2.132	1.820	1.451	1.025	.541
30	2.894	2.865	2.779	2.635	2.433	2.173	1.855	1.479	1.045	.551
45	2.949	2.920	2.832	2.685	2.479	2.214	1.891	1.507	1.065	.562
14° 45'	3.000	2.974	2.884	2.735	2.525	2.256	1.926	1.535	1.085	.572
15	3.058	3.028	2.937	2.785	2.571	2.297	1.961	1.564	1.105	.583
30	3.113	3.082	2.989	2.834	2.618	2.338	1.996	1.592	1.124	.593
45	3.168	3.136	3.042	2.884	2.664	2.379	2.031	1.620	1.144	.604
15° 45'	3.222	3.191	3.094	2.934	2.710	2.421	2.067	1.648	1.164	.614
15	3.277	3.245	3.147	2.984	2.756	2.462	2.102	1.676	1.184	.625
30	3.332	3.299	3.200	3.034	2.802	2.503	2.137	1.704	1.204	.635
45	3.387	3.354	3.252	3.084	2.848	2.544	2.172	1.732	1.224	.646
16° 45'	3.442	3.408	3.305	3.134	2.895	2.586	2.208	1.760	1.244	.656
16	3.496	3.462	3.358	3.184	2.941	2.627	2.243	1.789	1.264	.667

## TABLE OF ORDINATES—CONTINUED.

*Ordinates five feet apart.—Chord one hundred feet.*

Distances of the Ordinates from the end of the 100 feet Chord.										
Angle of Def'n.	Middle, 50 feet.	45 feet.	40 feet.	35 feet.	30 feet.	25 feet.	20 feet.	15 feet.	10 feet.	5 feet.
16 30	3-606	3-571	3-463	3-284	3-033	2-710	2-314	1-845	1-304	·688
17 30	3-716	3-680	3-569	3-384	3-125	2-792	2-384	1-902	1-344	·709
18 30	3-826	3-788	3-674	3-484	3-218	2-875	2-455	1-958	1-384	·730
19 30	3-935	3-897	3-779	3-584	3-310	2-958	2-525	2-014	1-424	·751
20 30	4-045	4-006	3-885	3-684	3-403	3-040	2-596	2-071	1-464	·772
21 30	4-155	4-115	3-990	3-784	3-495	3-123	2-666	2-127	1-504	·793
22 30	4-265	4-223	4-096	3-884	3-588	3-205	2-737	2-184	1-544	·814
23 30	4-375	4-332	4-201	3-984	3-680	3-288	2-808	2-240	1-583	·836
24 30	4-485	4-441	4-308	4-084	3-784	3-396	2-920	2-352	1-623	·857
25 30	4-595	4-549	4-412	4-184	3-884	3-495	3-020	2-467	1-663	·879
26 30	4-705	4-657	4-516	4-284	3-984	3-596	3-132	2-567	1-703	·900
27 30	4-815	4-766	4-622	4-384	4-084	3-696	3-240	2-667	1-743	·921
28 30	4-925	4-875	4-728	4-484	4-184	3-796	3-344	2-767	1-783	·942
29 30	5-035	4-984	4-834	4-584	4-284	3-896	3-444	2-867	1-823	·963
30 30	5-145	5-093	4-939	4-684	4-384	3-996	3-544	2-967	1-863	·984
31 30	5-255	5-202	5-045	4-784	4-484	4-096	3-644	3-067	1-903	1-005
32 30	5-365	5-311	5-151	4-884	4-584	4-196	3-744	3-167	1-943	1-026
33 30	5-475	5-420	5-258	4-984	4-684	4-296	3-844	3-267	1-983	1-047
34 30	5-585	5-529	5-365	5-084	4-784	4-396	3-944	3-367	2-023	1-068
35 30	5-695	5-638	5-472	5-184	4-884	4-496	4-044	3-467	2-063	1-089
36 30	5-805	5-747	5-579	5-284	4-984	4-596	4-144	3-567	2-103	1-110
37 30	5-915	5-856	5-687	5-384	5-084	4-696	4-244	3-667	2-143	1-131
38 30	6-025	5-965	5-795	5-484	5-184	4-796	4-344	3-767	2-183	1-152
39 30	6-135	6-074	5-903	5-584	5-284	4-896	4-444	3-867	2-223	1-173
40 30	6-245	6-183	6-011	5-684	5-384	4-996	4-544	3-967	2-263	1-194
41 30	6-355	6-292	6-119	5-784	5-484	5-096	4-644	4-067	2-303	1-215
42 30	6-465	6-401	6-227	5-884	5-584	5-196	4-744	4-167	2-343	1-236
43 30	6-575	6-510	6-335	5-984	5-684	5-296	4-844	4-267	2-383	1-257
44 30	6-685	6-619	6-443	6-084	5-784	5-396	4-944	4-367	2-423	1-278
45 30	6-795	6-728	6-551	6-184	5-884	5-496	5-044	4-467	2-463	1-299
46 30	6-905	6-837	6-659	6-284	5-984	5-596	5-144	4-567	2-503	1-320
47 30	7-015	6-946	6-767	6-384	6-084	5-696	5-244	4-667	2-543	1-341
48 30	7-125	7-055	6-875	6-484	6-184	5-796	5-344	4-767	2-583	1-362
49 30	7-235	7-164	6-975	6-584	6-284	5-896	5-444	4-867	2-623	1-383
50 30	7-345	7-273	7-085	6-684	6-384	5-996	5-544	4-967	2-663	1-404
51 30	7-455	7-382	7-193	6-784	6-484	6-096	5-644	5-067	2-703	1-425
52 30	7-565	7-491	7-299	6-884	6-584	6-196	5-744	5-167	2-743	1-446
53 30	7-675	7-599	7-407	6-984	6-684	6-296	5-844	5-267	2-783	1-467
54 30	7-785	7-708	7-514	7-084	6-784	6-396	5-944	5-367	2-823	1-488
55 30	7-895	7-817	7-622	7-184	6-884	6-496	6-044	5-467	2-863	1-509
56 30	8-005	7-926	7-729	7-284	6-984	6-596	6-144	5-567	2-903	1-530
57 30	8-115	8-035	7-837	7-384	7-084	6-696	6-244	5-667	2-943	1-551
58 30	8-225	8-144	7-939	7-484	7-184	6-796	6-344	5-767	2-983	1-572
59 30	8-335	8-253	8-041	7-584	7-284	6-896	6-444	5-867	3-023	1-593
60 30	8-445	8-362	8-139	7-684	7-384	6-996	6-544	5-967	3-063	1-614
61 30	8-555	8-471	8-247	7-784	7-484	7-096	6-644	6-067	3-103	1-635
62 30	8-665	8-580	8-355	7-884	7-584	7-196	6-744	6-167	3-143	1-656
63 30	8-775	8-689	8-463	7-984	7-684	7-296	6-844	6-267	3-183	1-677
64 30	8-885	8-798	8-571	8-084	7-784	7-396	6-944	6-367	3-223	1-698
65 30	8-995	8-907	8-675	8-184	7-884	7-496	7-044	6-467	3-263	1-719



## ARTICLE XXI.

## ON LONG CHORDS.

It is sometimes convenient, in preliminary locations, to lay off curves by chords longer than 100 feet. For instance, in fig. 19, instead of running from *a* by chords *ab*, *bc*, *cd*, &c. of but 100 feet, points *d*, *f*, *g*, &c. may be obtained with less trouble by using three times the tangential or deflection angles of the table, (as the case may be,) and employing chords *ad*, *df*, *fg*, &c. nearly three times as

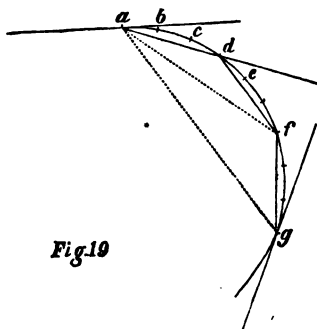


Fig 19

long as the chords *ab*, *bc*, &c.; or if *ad*, *df*, *fg* be either 2 or 4 stations apart, then 2 or 4 times the tangential and deflection angles would be used; and chords nearly 2 or 4 times 100 feet in length.

The following table contains the precise length of chord required to subtend respectively 1, 2, 3, or 4 stations. It is seldom desirable to exceed the latter limit.

TABLE OF LONG CHORDS.

Radius in feet.	Angle of Deflection.	Length of Chord in feet required to subtend			
		1 Station.	2 Stations.	3 Stations.	4 Stations.
5730.0	1°	100	200.0	300.0	400.0
4584.0	$1\frac{1}{4}^\circ$	100	200.0	300.0	399.9
3820.0	$1\frac{1}{2}^\circ$	100	200.0	300.0	399.9
3274.0	$1\frac{3}{4}^\circ$	100	200.0	300.0	399.8
2865.0	2°	100	200.0	299.9	399.7
2547.0	$2\frac{1}{4}^\circ$	100	200.0	299.9	399.6
2292.0	$2\frac{1}{2}^\circ$	100	200.0	299.8	399.5
2084.0	$2\frac{3}{4}^\circ$	100	200.0	299.8	399.4
1910.0	3°	100	200.0	299.7	399.3
1763.0	$3\frac{1}{4}^\circ$	100	200.0	299.7	399.2
1637.0	$3\frac{1}{2}^\circ$	100	200.0	299.6	399.1
1528.0	$3\frac{3}{4}^\circ$	100	200.0	299.6	399.0
1438.0	4°	100	199.9	299.6	398.9
1348.0	$4\frac{1}{4}^\circ$	100	199.9	299.5	398.7
1274.0	$4\frac{1}{2}^\circ$	100	199.9	299.4	398.5
1207.0	$4\frac{3}{4}^\circ$	100	199.9	299.3	398.3
1146.0	5°	100	199.9	299.2	398.0
1092.0	$5\frac{1}{4}^\circ$	100	199.8	299.1	397.8
1042.0	$5\frac{1}{2}^\circ$	100	199.8	299.0	397.6
996.8	$5\frac{3}{4}^\circ$	100	199.7	298.9	397.5
955.4	6°	100	199.7	298.8	397.3
917.0	$6\frac{1}{4}^\circ$	100	199.7	298.7	397.0
882.0	$6\frac{1}{2}^\circ$	100	199.7	298.6	396.7
849.3	$6\frac{3}{4}^\circ$	100	199.6	298.5	396.5
819.0	7°	100	199.6	298.4	396.2
790.8	$7\frac{1}{4}^\circ$	100	199.6	298.3	396.0
764.5	$7\frac{1}{2}^\circ$	100	199.6	298.2	395.7
739.9	$7\frac{3}{4}^\circ$	100	199.6	298.1	395.4
716.8	8°	100	199.6	298.0	395.1
695.1	$8\frac{1}{4}^\circ$	100	199.5	297.9	394.8
674.6	$8\frac{1}{2}^\circ$	100	199.5	297.8	394.5
655.5	$8\frac{3}{4}^\circ$	100	199.4	297.7	394.3
637.3	9°	100	199.4	297.5	394.1
620.2	$9\frac{1}{4}^\circ$	100	199.4	297.4	393.7
603.8	$9\frac{1}{2}^\circ$	100	199.3	297.3	393.2
588.4	$9\frac{3}{4}^\circ$	100	199.2	297.2	392.8
573.7	10°	100	199.2	297.0	392.4

For radii less than 573.7 feet, it is never required to use longer chords than 100 feet.

When this method of laying out curves by long chords is used, the instrument should be moved to each successive point after it is determined, in order to fix the next one, instead of attempting to obtain more than one point from one position of the instrument; because when the chords are longer than one chain, they cannot be measured in the right direction by eye, but must be guided by the instrument.

It must be especially borne in mind that, in any given curve, only the tangential and deflection *angles* increase in the same proportion as the number of 100 feet stations subtended by the long chord. Therefore, *these* long chords cannot be used for laying out curves *by eye*, as their tangential and deflection *distances* are not known.

When it is required to use long chords for turning a curve *by eye*, they must be composed of a number of *whole chains*, being made say 200, 300, or 400, &c. feet in length. The tangential and deflection *distances* of curves of more than 500 feet radius may then be assumed, in practice, to increase as the *squares* of the number of chains in the length of the long chord. For instance, to lay off a  $5^\circ$  curve by chords of 200, 300, or 400 feet in length, the tangential and deflection distances of the table must be multiplied by 4, 9, or 16, as the case may be. In this case the tangential and deflection *angles* are unknown.

This is not mathematically correct, but will answer in practice for the curves on a canal or common road, where great nicety is not needed.

The only proper instrument for running lines of survey is the *transit*, furnished with a compass and with a revolving telescope. The deflections being measured in *angles*, serve as a check to the numerous sources of error to which the compass is liable, arising from local attraction, electrical action in the glass cover, diurnal variation, &c. &c. Besides, when the compass alone is used, it is necessary to test every course or bearing from each end of each station; and this involves loss of time.

The following is a good form of field-book for the transit and compass combined.

Station.	Distance.	Total Distance.	Course.	Deflection in Degrees.		The right hand page is left blank for Remarks, and Sketches of Topography.
				Left.	Right.	

In every locating party there should be one person whose duty is to obtain, and record the transverse slopes of the ground at each station. His observations will usually extend to from fifty feet, to one hundred yards on each side of the centre stakes, depending on a variety of circumstances of locality which cannot be alluded to here. In preliminary locations these slopes need not be taken with very great nicety, as they will be used chiefly for ascertaining, approximately, the amount of excavation and embankment, by the rapid process described in my little volume on that subject, and which dispenses with nearly all the labor of the usual calculations.

After the final location is made, the slopes should be taken again, with great care, to the nearest quarter of a degree; but need not extend beyond the width actually occupied by the road. Their use in this second operation will be for determining the cubic contents with more precision than before, for final estimates; and also for obtaining the positions of the *side-stakes*.

Should the duty of *recording* these slopes devolve upon the compassman, (which it should not,) it will be necessary to add another column to his field-book, after that containing the deflections. In this column he will insert the slopes, thus, (Fig. 20.) the dot representing the center stake. The degrees of slope are written above the lines, and the distance in feet to which they extend, below.

Fig. 20.



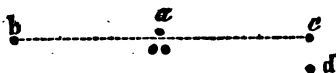
The slopes are taken by laying a long rod on the ground, at right angles to the line of survey, as nearly as may be judged by eye, and measuring the angles by means of a small *slope instrument* placed upon the rod. These are made by most of our instrument-makers.

## ARTICLE XXII.

### TO ADJUST A TRANSIT INSTRUMENT.

Having placed the transit firmly at *a*, fig. 21, and leveled it, clamp all fast, and direct the cross-hairs, by means of the tangent screw, to some convenient object, *b*. Then, revolving the telescope *vertically*, but without moving it in the least *horizontally*, let the cross-hairs fix upon a second

object in the opposite direction, as *c*; or, if there be no such object, place one, as for instance a chain-pin, at any convenient distance.



*Fig. 21*

Then unclamp the *lower* clamp, and revolve *horizontally* the entire upper part of the instrument above the parallel plates. Clamp it again, and fix the cross-hairs upon *b*; then again revolve the *telescope* vertically. If the sight now strikes *c*, as before, it is in adjustment; but if not, place another object, *d*, where it does strike; and with the adjusting pin alter the vertical cross-hair so as to strike halfway between *d* and *c*. The instrument will then be in adjustment.

Two or more trials will generally be needed before the adjustment is perfect.

With care, and on a firm floor, the operation may be performed in a long room, or by placing the instrument in a doorway communicating with two rooms of moderate size. Fine pins, or needles should then be used as the objects to be sighted at. It is better, however, to adjust out of doors, with more distant objects. It is also a good precaution to hang up a long plumb-line, or select some vertical object, and see whether the vertical hair coincides with it, as the telescope is raised or lowered. If from any accident, or carelessness in its construction, it does not, the defect must be remedied by an instrument-maker.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

0 Deg.

0 Deg.

0 Deg.

'	Sine.	La.g.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	0.000000	0.00000	Infinite.	1.000000	60	21	0.061086	0.06108	163.7001	9999813	39	41	0.119261	0.11927	83.84350
1	0.0002909	0.00291	3437.746	1.000000	59	22	0.063995	0.06399	156.2590	9999795	38	42	0.122170	0.12217	81.84704
2	0.0005818	0.00582	1718.873	9999998	58	23	0.066904	0.06690	149.4650	9999776	37	43	0.125079	0.12508	79.94343
3	0.0008727	0.00872	1145.915	9999996	57	24	0.069813	0.06981	143.2371	9999756	36	44	0.127987	0.12799	78.12634
4	0.0011636	0.01163	859.4363	9999993	56	25	0.072721	0.07272	137.5075	9999736	35	45	0.130896	0.13090	76.39000
5	0.0014544	0.01454	687.5488	9999989	55	26	0.075630	0.07563	132.2185	9999714	34	46	0.133805	0.13381	74.72916
6	0.0017453	0.01745	572.9572	9999985	54	27	0.078539	0.07854	127.3213	9999692	33	47	0.136713	0.13672	73.13899
7	0.0020362	0.02036	491.1060	9999979	53	28	0.081448	0.08145	122.7739	9999668	32	48	0.139622	0.13963	71.61507
8	0.0023271	0.02327	429.7175	9999973	52	29	0.084357	0.08436	118.5401	9999644	31	49	0.142530	0.14254	70.15334
9	0.0026180	0.02618	381.9709	9999966	51	30	0.087265	0.08726	114.5886	9999619	30	50	0.145439	0.14545	68.75008
10	0.0029089	0.02908	343.7737	9999958	50	31	0.090174	0.09017	110.8920	9999593	29	51	0.148348	0.14836	67.40185
11	0.0031998	0.03199	312.5213	9999949	49	32	0.093083	0.09308	107.4264	9999567	28	52	0.151256	0.15127	66.10547
12	0.0034907	0.03490	286.4777	9999939	48	33	0.095992	0.09599	104.1709	9999539	27	53	0.154165	0.15418	64.85800
13	0.0037815	0.03781	264.4408	9999928	47	34	0.098900	0.09890	101.1069	9999511	26	54	0.157073	0.15709	63.65674
14	0.0040724	0.04072	245.5519	9999917	46	35	0.101809	0.10181	98.21794	9999482	25	55	0.159982	0.16000	62.49915
15	0.0043633	0.04363	229.1816	9999905	45	36	0.104718	0.10472	95.48947	9999452	24	56	0.162890	0.16291	61.38290
16	0.0046542	0.04654	214.8576	9999892	44	37	0.107627	0.10763	92.90848	9999421	23	57	0.165799	0.16582	60.30582
17	0.0049451	0.04945	202.2187	9999878	43	38	0.110535	0.11054	90.46333	9999389	22	58	0.168707	0.16873	59.26587
18	0.0052360	0.05236	190.9841	9999863	42	39	0.113444	0.11345	88.14357	9999357	21	59	0.171616	0.17164	58.26117
19	0.0055268	0.05526	180.9322	9999847	41	40	0.116353	0.11636	85.93979	9999323	20	60	0.174524	0.17455	57.28996
20	0.0058177	0.05817	171.8854	9999831	40									56.28996	

Deg. 89

Deg. 89.

Deg. 89

## NATURAL SINES AND TANGENTS TO A RADIUS 1

1 Deg.

1 Deg.

1 Deg.

	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	-0.174524	-0.17455	57.28996	-9998477	60	21	-0.335598	-0.33566	42.43346	-9997224	39	41	-0.293755	-0.29388	34.02730
1	-0.177432	-0.17746	56.35059	-9998426	59	22	-0.338506	-0.33857	41.91579	-9997156	38	42	-0.296662	-0.29679	33.69350
2	-0.180341	-0.18037	55.44151	-9998374	58	23	-0.341414	-0.34148	41.41058	-9997086	37	43	-0.299570	-0.29970	33.36619
3	-0.183249	-0.18328	54.56130	-9998321	57	24	-0.344322	-0.34439	40.91741	-9997015	36	44	-0.302478	-0.30261	33.04517
4	-0.186158	-0.18619	53.70858	-9998267	56	25	-0.347230	-0.34730	40.43583	-9996943	35	45	-0.305385	-0.30552	32.73026
5	-0.189066	-0.18910	52.88211	-9998213	55	26	-0.350138	-0.35021	39.96546	-9996871	34	46	-0.308293	-0.30843	32.42129
6	-0.191974	-0.19201	52.08067	-9998157	54	27	-0.353046	-0.35312	39.50589	-9996798	33	47	-0.311200	-0.31135	32.11809
7	-0.194883	-0.19492	51.30315	-9998101	53	28	-0.355954	-0.35603	39.05677	-9996724	32	48	-0.314108	-0.31426	31.82051
8	-0.197791	-0.19783	50.54850	-9998044	52	29	-0.358862	-0.35894	38.61773	-9996649	31	49	-0.317015	-0.31717	31.52839
9	-0.200699	-0.20074	49.81572	-9997986	51	30	-0.361769	-0.36185	38.18845	-9996573	30	50	-0.319922	-0.32008	31.24157
10	-0.203608	-0.20365	49.10388	-9997927	50	31	-0.364677	-0.36477	37.76861	-9996497	29	51	-0.322830	-0.32299	30.95992
11	-0.206516	-0.20656	48.41208	-9997867	49	32	-0.367585	-0.36768	37.35789	-9996419	28	52	-0.325737	-0.32591	30.68330
12	-0.209424	-0.20947	47.73950	-9997807	48	33	-0.370493	-0.37059	36.95600	-9996341	27	53	-0.328644	-0.32882	30.41158
13	-0.212332	-0.21238	47.08534	-9997745	47	34	-0.373401	-0.37350	36.56265	-9996262	26	54	-0.331552	-0.33173	30.14461
14	-0.215241	-0.21529	46.44896	-9997683	46	35	-0.376309	-0.37641	36.17759	-9996182	25	55	-0.334459	-0.33464	29.88229
15	-0.218149	-0.21820	45.82935	-9997620	45	36	-0.379216	-0.37932	35.80055	-9996101	24	56	-0.337366	-0.33755	29.62449
16	-0.221057	-0.22111	45.22614	-9997556	44	37	-0.382124	-0.38223	35.43128	-9996020	23	57	-0.340274	-0.34047	29.37110
17	-0.223965	-0.22402	44.63859	-9997492	43	38	-0.385032	-0.38514	35.06954	-9995937	22	58	-0.343181	-0.34338	29.12200
18	-0.226873	-0.22693	44.06611	-9997426	42	39	-0.387940	-0.38805	34.71511	-9995854	21	59	-0.346088	-0.34629	28.87708
19	-0.229781	-0.22984	43.50812	-9997360	41	40	-0.390847	-0.39097	34.36777	-9995770	20	60	-0.348995	-0.34920	28.63625
20	-0.232690	-0.23275	42.96407	-9997292	40										

Deg. 88.

Deg. 88.

Deg. 88.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

2 Deg.

2 Deg.

2 Deg.

/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	0.0348995	0.034920	28.63625	9993908	60	21	-0.410037	-0.41038	24.36750	9991590	39	41	-0.468159	-0.46867	21.33685
1	0.0351902	0.035212	28.39939	9993806	59	22	-0.412944	-0.41329	24.19571	9991470	38	42	-0.471065	-0.47158	21.20494
2	0.0354809	0.035503	28.16642	9993704	58	23	-0.415850	-0.41621	24.02632	9991350	37	43	-0.473970	-0.47450	21.07466
3	0.0357716	0.035794	27.93723	9993600	57	24	-0.418757	-0.41912	23.85927	9991228	36	44	-0.476876	-0.47741	20.94596
4	0.0360623	0.036085	27.71174	9993495	56	25	-0.421663	-0.42203	23.69453	9991106	35	45	-0.479781	-0.48033	20.81882
5	0.0363530	0.036377	27.48985	9993390	55	26	-0.424569	-0.42495	23.53205	9990983	34	46	-0.482687	-0.48325	20.69322
6	0.0366437	0.036668	27.27148	9993284	54	27	-0.427475	-0.42786	23.37177	9990859	33	47	-0.485592	-0.48616	20.56911
7	0.0369344	0.036959	27.05655	9993177	53	28	-0.430382	-0.43078	23.21366	9990734	32	48	-0.488498	-0.48908	20.44648
8	0.0372251	0.037250	26.84498	9993069	52	29	-0.433288	-0.43369	23.05767	9990609	31	49	-0.491403	-0.49199	20.32530
9	0.0375158	0.037542	26.63669	9992960	51	30	-0.436194	-0.43660	22.90376	9990482	30	50	-0.494308	-0.49491	20.20555
10	0.0378065	0.037833	26.43160	9992851	50	31	-0.439100	-0.43952	22.75189	9990355	29	51	-0.497214	-0.49782	20.08719
11	0.0380971	0.038124	26.22963	9992740	49	32	-0.442006	-0.44243	22.60201	9990227	28	52	-0.500119	-0.50074	19.97021
12	0.0383878	0.038416	26.03073	9992629	48	33	-0.444912	-0.44535	22.45409	9990098	27	53	-0.503024	-0.50366	19.85459
13	0.0386785	0.038707	25.83482	9992517	47	34	-0.447818	-0.44826	22.30809	9989968	26	54	-0.505929	-0.50657	19.74029
14	0.0389692	0.038998	25.64183	9992404	46	35	-0.450724	-0.45118	22.16398	9989837	25	55	-0.508835	-0.50949	19.62729
15	0.0392598	0.039290	25.45170	9992290	45	36	-0.453630	-0.45409	22.02171	9989706	24	56	-0.511740	-0.51241	19.51558
16	0.0395505	0.039581	25.26436	9992176	44	37	-0.456536	-0.45701	21.88125	9989573	23	57	-0.514645	-0.51532	19.40513
17	0.0398411	0.039872	25.07975	9992060	43	38	-0.459442	-0.45992	21.74256	9989440	22	58	-0.517550	-0.51824	19.29592
18	0.0401318	0.040164	24.89782	9991944	42	39	-0.462347	-0.46284	21.60563	9989306	21	59	-0.520455	-0.52116	19.18793
19	0.0404224	0.040455	24.71851	9991827	41	40	-0.465253	-0.46575	21.47040	9989171	20	60	-0.523360	-0.52407	19.08113
20	0.0407131	0.040746	24.54175	9991709	40					9989036				-0.52697	18.97447
/	Cosine.	Cotan.	Tang.	Sine.	/	Cosine.	Cotan.	Tang.	Sine.	/	Cosine.	Cotan.	Tang.	Sine.	/

Deg. 87.

Deg. 87.

Deg. 87.



## NATURAL SINES AND TANGENTS TO A RADIUS 1.

3 Deg.

3 Deg.

3 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	0.0523361	0.052407	19.08113	0.9986295	60	0.21	0.584352	17.08372	0.9982912	39	0.41	0.642420	15.53398	0.9979343	19
1	0.0526264	0.052699	18.97552	0.9986143	59	0.22	0.587256	16.99895	0.9982742	38	0.42	0.645323	15.46381	0.9979156	18
2	0.0529169	0.052991	18.87106	0.9985989	58	0.23	0.590160	16.91502	0.9982570	37	0.43	0.648226	15.39427	0.9978968	17
3	0.0532074	0.053282	18.76775	0.9985835	57	0.24	0.593064	16.83191	0.9982398	36	0.44	0.651129	15.32535	0.9978779	16
4	0.0534979	0.053574	18.66556	0.9985680	56	0.25	0.595967	16.74961	0.9982225	35	0.45	0.654031	15.25705	0.9978589	15
5	0.0537883	0.053866	18.56447	0.9985524	55	0.26	0.598871	16.66811	0.9982052	34	0.46	0.656934	15.18934	0.9978399	14
6	0.0540788	0.054158	18.46447	0.9985367	54	0.27	0.601775	16.58739	0.9981877	33	0.47	0.659836	15.12224	0.9978207	13
7	0.0543693	0.054449	18.36553	0.9985209	53	0.28	0.604678	16.50745	0.9981701	32	0.48	0.662739	15.05572	0.9978015	12
8	0.0546597	0.054741	18.26765	0.9985050	52	0.29	0.607582	16.42827	0.9981525	31	0.49	0.665641	14.98978	0.9977821	11
9	0.0549502	0.055033	18.17080	0.9984891	51	0.30	0.610485	16.34985	0.9981348	30	0.50	0.668544	14.92441	0.9977627	10
10	0.0552406	0.055325	18.07497	0.9984731	50	0.31	0.613389	16.27217	0.9981170	29	0.51	0.671446	14.85961	0.9977433	9
11	0.0555311	0.055616	17.98015	0.9984570	49	0.32	0.616292	16.19522	0.9980991	28	0.52	0.674349	14.79537	0.9977237	8
12	0.0558215	0.055908	17.88631	0.9984408	48	0.33	0.619196	16.11899	0.9980811	27	0.53	0.677251	14.73167	0.9977040	7
13	0.0561119	0.056200	17.79344	0.9984245	47	0.34	0.622099	16.04348	0.9980631	26	0.54	0.680153	14.66852	0.9976843	6
14	0.0564024	0.056492	17.70152	0.9984081	46	0.35	0.625002	15.96866	0.9980450	25	0.55	0.683055	14.60591	0.9976645	5
15	0.0566928	0.056784	17.61055	0.9983917	45	0.36	0.627905	15.89454	0.9980267	24	0.56	0.685957	14.54383	0.9976445	4
16	0.0569832	0.057075	17.52051	0.9983751	44	0.37	0.630808	15.82110	0.9980084	23	0.57	0.688859	14.48227	0.9976245	3
17	0.0572736	0.057367	17.43138	0.9983585	43	0.38	0.633711	15.74833	0.9979900	22	0.58	0.691761	14.42123	0.9976045	2
18	0.0575640	0.057659	17.34315	0.9983418	42	0.39	0.636614	15.67623	0.9979716	21	0.59	0.694663	14.36069	0.9975843	1
19	0.0578544	0.057951	17.25580	0.9983250	41	0.40	0.639517	15.60478	0.9979530	20	0.60	0.697565	14.30066	0.9975641	0
20	0.0581448	0.058243	17.16933	0.9983082	40										
'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'

Deg. 86.

Deg. 86.

Deg. 86.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

4 Deg.

4 Deg.

4 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	0.0697565	0.069926	14.30066	9975641	60	21	0.758489	0.76068	13.14612	9971193	39	41	0.816486	0.81922	12.20671
1	0.0700467	0.070219	14.24113	9975437	59	22	0.761390	0.76360	13.09575	9970972	38	42	0.819385	0.82215	12.16323
2	0.0703368	0.070511	14.18209	9975233	58	23	0.764290	0.76653	13.04576	9970750	37	43	0.822284	0.82507	12.12006
3	0.0706270	0.070803	14.12353	9975028	57	24	0.767190	0.76945	12.99616	9970528	36	44	0.825183	0.82800	12.07719
4	0.0709171	0.071096	14.06545	9974822	56	25	0.770091	0.77238	12.94692	9970304	35	45	0.828082	0.83093	12.03462
5	0.0712073	0.071388	14.00785	9974615	55	26	0.772991	0.77531	12.89805	9970080	34	46	0.830981	0.83386	11.99234
6	0.0714974	0.071680	13.95071	9974408	54	27	0.775891	0.77823	12.84955	9969854	33	47	0.833880	0.83679	11.95037
7	0.0717876	0.071973	13.89404	9974199	53	28	0.778791	0.78116	12.80141	9969628	32	48	0.836778	0.83972	11.90868
8	0.0720777	0.072265	13.83782	9973990	52	29	0.781691	0.78409	12.75363	9969401	31	49	0.839677	0.84265	11.86728
9	0.0723678	0.072558	13.78206	9973780	51	30	0.784591	0.78701	12.70626	9969173	30	50	0.842576	0.84558	11.82616
10	0.0726580	0.072850	13.72673	9973569	50	31	0.787491	0.78994	12.65912	9968945	29	51	0.845474	0.84851	11.78533
11	0.0729481	0.073143	13.67185	9973357	49	32	0.790391	0.79287	12.61239	9968715	28	52	0.848373	0.85144	11.74477
12	0.0732382	0.073435	13.61740	9973145	48	33	0.793290	0.79579	12.56599	9968485	27	53	0.851271	0.85437	11.70450
13	0.0735283	0.073727	13.56339	9972931	47	34	0.796190	0.79872	12.51994	9968254	26	54	0.854169	0.85730	11.66449
14	0.0738184	0.074020	13.50979	9972717	46	35	0.799090	0.80165	12.47422	9968022	25	55	0.857067	0.86023	11.62476
15	0.0741085	0.074312	13.45662	9972502	45	36	0.801989	0.80458	12.42883	9967789	24	56	0.859966	0.86316	11.58529
16	0.0743986	0.074605	13.40386	9972286	44	37	0.804889	0.80750	12.38376	9967555	23	57	0.862864	0.86609	11.54609
17	0.0746887	0.074897	13.35151	9972069	43	38	0.807788	0.81043	12.33902	9967321	22	58	0.865762	0.86902	11.50715
18	0.0749787	0.075190	13.29957	9971851	42	39	0.810687	0.81336	12.29460	9967085	21	59	0.868660	0.87195	11.46847
19	0.0752688	0.075492	13.24803	9971633	41	40	0.813597	0.81629	12.25050	9966849	20	60	0.871557	0.87488	11.43005
20	0.0755589	0.075775	13.19698	9971413	40										
'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'

Deg. 85.

Deg. 85.

Deg. 85.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

5 Deg.

5 Deg.

5 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	0.0871557	0.087488	11.43005	0.9961947	60.21	0.932395	0.93647	10.67834	0.956437	39.41	0.990303	0.99519	10.04828	0.9950844	19
1	0.0874455	0.087781	11.39188	0.9961693	59.22	0.935291	0.93940	10.64499	0.956165	38.42	0.993197	0.99813	10.01871	0.9950556	18
2	0.0877353	0.088074	11.35397	0.9961438	58.23	0.938187	0.94234	10.61184	0.955892	37.43	0.996092	1.00107	9.989305	0.9950266	17
3	0.0880251	0.088368	11.31630	0.9961183	57.24	0.941083	0.94527	10.57889	0.955620	36.44	0.998986	1.00400	9.960072	0.9949976	16
4	0.0883148	0.088661	11.27888	0.9960926	56.25	0.943979	0.94821	10.54615	0.955345	35.45	1.001381	1.00694	9.931008	0.9949685	15
5	0.0886046	0.088954	11.24171	0.9960669	55.26	0.946875	0.95114	10.51360	0.955070	34.46	1.004775	1.00988	9.902112	0.9949393	14
6	0.0888943	0.089247	11.20478	0.9960411	54.27	0.949771	0.95408	10.48126	0.954794	33.47	1.007669	1.01282	9.873382	0.9949101	13
7	0.0891840	0.089540	11.16808	0.9960152	53.28	0.952666	0.95701	10.44911	0.954517	32.48	1.010563	1.01576	9.844816	0.9948807	12
8	0.0894738	0.089834	11.13163	0.9959892	52.29	0.955562	0.95995	10.41715	0.954240	31.49	1.013457	1.01870	9.816414	0.9948513	11
9	0.0897635	0.090127	11.09541	0.9959631	51.30	0.958458	0.96289	10.38539	0.953962	30.50	1.016351	1.02164	9.788173	0.9948217	10
10	0.0900532	0.090420	11.05943	0.9959370	50.31	0.961353	0.96582	10.35382	0.953683	29.51	1.019245	1.02458	9.760092	0.9947921	9
11	0.0903429	0.090713	11.02367	0.9959107	49.32	0.964248	0.96876	10.32244	0.953403	28.52	1.022138	1.02752	9.732171	0.9947625	8
12	0.0906326	0.091007	10.98815	0.9958844	48.33	0.967144	0.97169	10.29125	0.953122	27.53	1.025032	1.03046	9.704407	0.9947327	7
13	0.0909223	0.091300	10.95285	0.9958580	47.34	0.970039	0.97463	10.26024	0.952840	26.54	1.027925	1.03339	9.676800	0.9947028	6
14	0.0912119	0.091593	10.91777	0.9958315	46.35	0.972934	0.97757	10.22942	0.952557	25.55	1.030819	1.03634	9.649347	0.9946729	5
15	0.0915016	0.091887	10.88292	0.9958049	45.36	0.975829	0.98050	10.19878	0.952274	24.56	1.033712	1.03928	9.622048	0.9946428	4
16	0.0917913	0.092180	10.84828	0.9957783	44.37	0.978724	0.98344	10.16833	0.951990	23.57	1.036605	1.04222	9.594902	0.9946127	3
17	0.0920809	0.092473	10.81387	0.9957515	43.38	0.981619	0.98638	10.13805	0.951705	22.58	1.039499	1.04516	9.567906	0.9945825	2
18	0.0923706	0.092767	10.77967	0.9957247	42.39	0.984514	0.98932	10.10795	0.951419	21.59	1.042392	1.04810	9.541061	0.9945523	1
19	0.0926602	0.093060	10.74568	0.9956978	41.40	0.987408	0.99225	10.07803	0.951132	20.60	1.045285	1.05104	9.514364	0.9945219	0
20	0.0929499	0.093354	10.71191	0.9956708	40										

Deg. 84.

Deg. 84.

Deg. 84.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

6 Deg.

6 Deg.

6 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	1045285	105104	9.514364	9945219	60	21	1106017	111284	8.98584	39	41	1163818	117178	8.534017	9932045
1	1048178	105398	9.487814	9944914	59	22	1108908	111578	8.962866	38	42	1166707	117473	8.512594	9931706
2	1051070	105692	9.461411	9944609	58	23	1111799	111873	8.938672	37	43	1169596	117767	8.491277	9931367
3	1053963	105986	9.435153	9944303	57	24	1114689	112168	8.915200	36	44	1172485	118062	8.470065	9931026
4	1056856	106280	9.409038	9943996	56	25	1117580	112462	8.891850	35	45	1175374	118357	8.448957	9930685
5	1059748	106575	9.383066	9943688	55	26	1120471	112757	8.868620	34	46	1178263	118652	8.427953	9930342
6	1062641	106869	9.357235	9943379	54	27	1123361	113051	8.845510	33	47	1181151	118947	8.407051	9929999
7	1065533	107163	9.331545	9943070	53	28	1126252	113346	8.822518	32	48	1184040	119242	8.386251	9929655
8	1068425	107457	9.305993	9942760	52	29	1129142	113641	8.799644	31	49	1186928	119537	8.365553	9929310
9	1071318	107751	9.280580	9942448	51	30	1132032	113935	8.776887	30	50	1189816	119832	8.344955	9928965
10	1074210	108046	9.255303	9942136	50	31	1134922	114230	8.754246	29	51	1192704	120127	8.324457	9928618
11	1077102	108340	9.230162	9941823	49	32	1137812	114525	8.731719	28	52	1195593	120423	8.304058	9928271
12	1079994	108634	9.205156	9941510	48	33	1140702	114819	8.709307	27	53	1198481	120718	8.283757	9927922
13	1082885	108929	9.180283	9941195	47	34	1143592	115114	8.687008	26	54	1201368	121013	8.263554	9927573
14	1085777	109223	9.155543	9940880	46	35	1146482	115409	8.664822	25	55	1204256	121308	8.243448	9927224
15	1088669	109517	9.130934	9940563	45	36	1149372	115703	8.642747	24	56	1207144	121603	8.223438	9926873
16	1091560	109812	9.106456	9940246	44	37	1152261	115998	8.620783	23	57	1210031	121898	8.203533	9926521
17	1094452	110106	9.082107	9939928	43	38	1155151	116293	8.598929	22	58	1212919	122194	8.183704	9926169
18	1097343	110401	9.057886	9939610	42	39	1158040	116588	8.577183	21	59	1215806	122489	8.163978	9925816
19	1100234	110695	9.033793	9939290	41	40	1160929	116883	8.555546	20	60	1218693	122784	8.144346	9925462
20	1103126	110989	9.009826	9938969	40										
'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'

Deg. 83.

Deg. 83.

Deg. 83.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

7 Deg.

7 Deg.

7 Deg.

	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	1218693	122784	8-144346	9925462	6021	1279302	128990	7-752536	9917832	3941	1336979	134909	7-412397	9910221	19
1	1221581	123079	8-124807	9925107	5922	1282186	129285	7-734802	9917459	3842	1339882	135205	7-396159	9909832	18
2	1224468	123375	8-105359	9924751	5823	1285071	129581	7-717148	9917086	3743	1342744	135501	7-379990	9909442	17
3	1227355	123670	8-086004	9924394	5724	1287956	129877	7-699573	9916712	3644	1345627	135797	7-363891	9909051	16
4	1230241	123965	8-066739	9924037	5625	1290841	130173	7-682076	9916337	3545	1348509	136094	7-347861	9908659	15
5	1233128	124261	8-047564	9923679	5526	1293725	130469	7-664658	9915961	3446	1351392	136390	7-331898	9908266	14
6	1236015	124556	8-028479	9923319	5427	1296609	130764	7-647317	9915584	3347	1354274	136686	7-316004	9907873	13
7	1238901	124852	8-009483	9922959	5328	1299494	131060	7-630053	9915206	3248	1357156	136983	7-300178	9907478	12
8	1241788	125147	7-990575	9922599	5229	1302378	131356	7-612865	9914928	3149	1360038	137279	7-284418	9907083	11
9	1244674	125442	7-971755	9922237	5130	1305262	131652	7-595754	9914449	3050	1362919	137575	7-268725	9906687	10
10	1247560	125738	7-953022	9921874	5031	1308146	131948	7-578717	9914069	2951	1365801	137872	7-253098	9906290	9
11	1250446	126033	7-934375	9921511	4932	1311030	132244	7-561756	9913689	2852	1368683	138169	7-237537	9905893	8
12	1253332	126329	7-915815	9921147	4833	1313913	132540	7-544869	9913306	2753	1371564	138465	7-222042	9905494	7
13	1256218	126624	7-897339	9920782	4734	1316797	132836	7-528057	9912923	2654	1374427	138761	7-206611	9905095	6
14	1259104	126920	7-878948	9920416	4635	1319681	133132	7-511317	9912540	2555	1377327	139058	7-191245	9904694	5
15	1261990	127216	7-860642	9920049	4536	1322564	133428	7-494651	9912155	2456	1380208	139354	7-175943	9904293	4
16	1264876	127511	7-842419	9919682	4437	1325447	133724	7-478057	9911770	2357	1383089	139651	7-160705	9903891	3
17	1267761	127807	7-824279	9919314	4338	1328330	134020	7-461535	9911384	2258	1385970	139947	7-145530	9903489	2
18	1270646	128103	7-806221	9918944	4239	1331213	134316	7-445085	9910997	2159	1388850	140244	7-130419	9903085	1
19	1273531	128398	7-788245	9918574	4140	1334096	134612	7-428706	9910610	2060	1391731	140540	7-115369	9902681	0
20	1276416	128694	7-770350	9918204	40										
	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'

Deg. 82.

Deg. 82.

Deg. 82.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

8 Deg.

8 Deg.

8 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	1391731	140540	7-115369	9902681	60	21	1452197	146775	6-813122	39	41	1509733	152723	6-547767	9885378
1	1394612	140837	7-100382	9902275	59	22	1455075	147072	6-799356	38	42	1512608	153021	6-535029	9884939
2	1397492	141134	7-085457	9901869	58	23	1457953	147369	6-785644	37	43	1515484	153319	6-522339	9884498
3	1400372	141430	7-070593	9901462	57	24	1460830	147667	6-791986	36	44	1518359	153617	6-509698	9884057
4	1403252	141727	7-055790	9901055	56	25	1463708	147964	6-758382	35	45	1521234	153914	6-497104	9883615
5	1406132	142024	7-041048	9900646	55	26	1466585	148261	6-744831	34	46	1524109	154212	6-484558	9883172
6	1409012	142321	7-026366	9900237	54	27	1469463	148559	6-731334	33	47	1526984	154510	6-472059	9882728
7	1411892	142617	7-011744	9899826	53	28	1472340	148856	6-717889	32	48	1529858	154808	6-459607	9882284
8	1414772	142914	6-997180	9899415	52	29	1475217	149153	6-704496	31	49	1532733	155106	6-447201	9881838
9	1417651	143211	6-982678	9899003	51	30	1478094	149451	6-691156	30	50	1535607	155404	6-434842	9881392
10	1420531	143508	6-968233	9898590	50	31	1480971	149748	6-677867	29	51	1538482	155701	6-422530	9880945
11	1423410	143805	6-953847	9898177	49	32	1483848	150045	6-664630	28	52	1541356	155999	6-410263	9880497
12	1426289	144102	6-939519	9897762	48	33	1486724	150343	6-651444	27	53	1544230	156297	6-398042	9880048
13	1429168	144399	6-925248	9897347	47	34	1489601	150640	6-638310	26	54	1547104	156595	6-385866	9879599
14	1432047	144696	6-911035	9896931	46	35	1492477	150938	6-625225	25	55	1549978	156893	6-373735	9879148
15	1434926	144993	6-896879	9896514	45	36	1495353	151235	6-612191	24	56	1552851	157191	6-361650	9878697
16	1437805	145290	6-882780	9896096	44	37	1498230	151533	6-599208	23	57	1555725	157490	6-349609	9878245
17	1440684	145587	6-868737	9895677	43	38	1501106	151830	6-586273	22	58	1558598	157788	6-337612	9877792
18	1443562	145884	6-854750	9895258	42	39	1503981	152128	6-573389	21	59	1561472	158086	6-325660	9877338
19	1446440	146181	6-840819	9894838	41	40	1506857	152426	6-560553	20	60	1564345	158384	6-313751	9876883
20	1449319	146478	6-826943	9894416	40										
'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'	Cosine.	Cotan.	Tang.	Sine.	'

Deg. 81.

Deg. 81.

Deg. 81.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

9 Deg.

9 Deg.

9 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	°	Sine.	Tang.	Cotang.	Cosine.	°	Sine.	Tang.	Cotang.	Cosine.	°
0	.1561345	.158384	6.313751	.9876883	60	.21	.1624650	.164652	6.073397	.9867143	39	.41	.1682026	.170633	5.860505
1	.1567218	.158682	6.301886	.9876428	59	.22	.1627520	.164951	6.062396	.9866670	38	.42	.1684894	.170933	5.850241
2	.1570091	.158980	6.290065	.9875972	58	.23	.1630390	.165250	6.051434	.9866196	37	.43	.1687761	.171232	5.840011
3	.1572963	.159277	6.278286	.9875514	57	.24	.1633260	.165518	6.040510	.9865728	36	.44	.1690628	.171532	5.829817
4	.1575836	.159579	6.266351	.9875057	56	.25	.1636129	.165847	6.029624	.9865246	35	.45	.1693495	.171831	5.819657
5	.1578708	.159875	6.254858	.9874598	55	.26	.1638999	.166146	6.018777	.9864770	34	.46	.1696362	.172130	5.809531
6	.1581581	.160174	6.243208	.9874138	54	.27	.1641868	.166445	6.007967	.9864293	33	.47	.1699228	.172430	5.799440
7	.1584453	.160472	6.231600	.9873678	53	.28	.1644738	.166744	5.997195	.9863815	32	.48	.1702095	.172730	5.789382
8	.1587325	.160770	6.220034	.9873216	52	.29	.1647607	.167043	5.986461	.9863336	31	.49	.1704961	.173029	5.779358
9	.1590197	.161069	6.208510	.9872754	51	.30	.1650476	.167342	5.975764	.9862856	30	.50	.1707828	.173329	5.769368
10	.1593069	.161367	6.197027	.9872291	50	.31	.1653345	.167641	5.965104	.9862375	29	.51	.1710694	.173628	5.759412
11	.1595940	.161666	6.185586	.9871827	49	.32	.1656214	.167940	5.954481	.9861894	28	.52	.1713560	.173928	5.749488
12	.1598812	.161964	6.174186	.9871363	48	.33	.1659082	.168239	5.943895	.9861412	27	.53	.1716425	.174228	5.739598
13	.1601683	.162262	6.162827	.9870897	47	.34	.1661951	.168539	5.933345	.9860929	26	.54	.1719291	.174527	5.729741
14	.1604555	.162561	6.151508	.9870431	46	.35	.1664819	.168838	5.922832	.9860445	25	.55	.1722156	.174827	5.719917
15	.1607426	.162860	6.140230	.9869964	45	.36	.1667687	.169137	5.912355	.9859960	24	.56	.1725022	.175127	5.710125
16	.1610297	.163159	6.128992	.9869496	44	.37	.1670556	.169436	5.901913	.9859475	23	.57	.1727887	.175427	5.700366
17	.1613167	.163457	6.117794	.9869027	43	.38	.1673423	.169735	5.891508	.9858988	22	.58	.1730752	.175727	5.690639
18	.1616038	.163756	6.106636	.9868557	42	.39	.1676291	.170035	5.881138	.9858501	21	.59	.1733617	.176027	5.680944
19	.1618909	.164055	6.095517	.9868087	41	.40	.1679159	.170334	5.870804	.9858013	20	.60	.1736482	.176327	5.671281
20	.1621779	.164353	6.084438	.9867615	40										

Deg. 80.

Deg. 80.

Deg. 80.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

10 Deg.

10 Deg.

10 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	'	'	Sine.	Tang.	Cotang.	Cosine.	'	'	Sine.	Tang.	Cotang.	Cosine.	'	'
0	.1736482	.176327	5.671281	.9848078	60	21	.1795607	.182632	5.475478	.9837286	39	41	.1853808	.188650	5.300801	.9826668	19	
1	.1739346	.176626	5.661650	.9847572	59	22	.1799469	.182933	5.466481	.9836763	38	42	.1856666	.188932	5.292350	.9826128	18	
2	.1742211	.176926	5.652051	.9847066	58	23	.1802330	.183233	5.457512	.9835823	37	43	.1859524	.189253	5.283925	.9825587	17	
3	.1745075	.177226	5.642483	.9846558	57	24	.1805191	.183534	5.448571	.9835153	36	44	.1862382	.189554	5.275525	.9825046	16	
4	.1747939	.177527	5.632947	.9846050	56	25	.1808052	.183835	5.439559	.9834483	35	45	.1865240	.189855	5.267151	.9824504	15	
5	.1750803	.177827	5.623442	.9845542	55	26	.1810913	.184135	5.430775	.9833816	34	46	.1868098	.190157	5.258803	.9823961	14	
6	.1753667	.178127	5.613968	.9845032	54	27	.1813774	.184436	5.421918	.9833149	33	47	.1870956	.190458	5.250480	.9823417	13	
7	.1756531	.178427	5.604524	.9844521	53	28	.1816635	.184737	5.413090	.9832482	32	48	.1873813	.190760	5.242183	.9822873	12	
8	.1759395	.178727	5.595112	.9844010	52	29	.1819495	.185038	5.404290	.9831815	31	49	.1876670	.191061	5.233911	.9822327	11	
9	.1762258	.179027	5.585730	.9843498	51	30	.1822355	.185339	5.395517	.9831148	30	50	.1879528	.191363	5.225664	.9821781	10	
10	.1765121	.179327	5.576378	.9842985	50	31	.1825215	.185639	5.386771	.9830481	29	51	.1882385	.191664	5.217442	.9821234	9	
11	.1767984	.179628	5.567057	.9842471	49	32	.1828075	.185940	5.378053	.9829814	28	52	.1885241	.191966	5.209245	.9820686	8	
12	.1770847	.179928	5.557766	.9841956	48	33	.1830935	.186241	5.369363	.9829147	27	53	.1888098	.192268	5.201073	.9820137	7	
13	.1773710	.180228	5.548505	.9841441	47	34	.1833795	.186542	5.360699	.9828480	26	54	.1890954	.192569	5.192926	.9819587	6	
14	.1776573	.180529	5.539274	.9840924	46	35	.1836654	.186843	5.352062	.9827813	25	55	.1893811	.192871	5.184803	.9819037	5	
15	.1779435	.180829	5.530072	.9840407	45	36	.1839514	.187144	5.343452	.9827146	24	56	.1896667	.193173	5.176705	.9818485	4	
16	.1782298	.181129	5.520900	.9839889	44	37	.1842373	.187446	5.334869	.9826479	23	57	.1899523	.193474	5.168631	.9817933	3	
17	.1785160	.181430	5.511757	.9839370	43	38	.1845232	.187747	5.326313	.9825812	22	58	.1902379	.193776	5.160581	.9817380	2	
18	.1788022	.181730	5.502644	.9838850	42	39	.1848091	.188048	5.317783	.9825145	21	59	.1905234	.194078	5.152555	.9816826	1	
19	.1790884	.182031	5.493560	.9838330	41	40	.1850949	.188349	5.309279	.9824478	20	60	.1908090	.194380	5.144554	.9816272	0	
20	.1793746	.182331	5.484505	.9837808	40													

Deg. 79.

Deg. 79.

Deg. 79.



## NATURAL SINES AND TANGENTS TO A RADIUS 1.

11 Deg.

11 Deg.

11 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'			
0	.1908090	.194380	5.144554	.9816272	60	.21	.1963018	.200727	4.981881		.9804433	39	.41	.2025024	.206786	4.835901	.9792818	19
1	.1910945	.194682	5.136576	.9815716	59	.22	.1970870	.201030	4.974381		.9803860	38	.42	.2027873	.207090	4.828817	.9792228	18
2	.1913801	.194984	5.128622	.9815160	58	.23	.1973722	.201332	4.966903		.9803286	37	.43	.2030721	.207393	4.821753	.9791638	17
3	.1916656	.195286	5.120692	.9814603	57	.24	.1976573	.201635	4.959447		.9802712	36	.44	.2033569	.207696	4.814709	.9791047	16
4	.1919510	.195588	5.112785	.9814045	56	.25	.1979425	.201938	4.952012		.9802136	35	.45	.2036418	.208000	4.807685	.9790455	15
5	.1922365	.195890	5.104902	.9813486	55	.26	.1982276	.202240	4.944599		.9801560	34	.46	.2039265	.208303	4.800680	.9789862	14
6	.1925220	.196192	5.097042	.9812927	54	.27	.1985127	.202543	4.937206		.9800985	33	.47	.2042113	.208607	4.793695	.9789268	13
7	.1928074	.196494	5.089206	.9812366	53	.28	.1987978	.202846	4.929835		.9800405	32	.48	.2044961	.208910	4.786730	.9788674	12
8	.1930928	.196796	5.081392	.9811805	52	.29	.1990829	.203149	4.922485		.9799827	31	.49	.2047808	.209214	4.779783	.9788079	11
9	.1933782	.197098	5.073602	.9811243	51	.30	.1993679	.203452	4.915157		.9799247	30	.50	.2050655	.209518	4.772856	.9787483	10
10	.1936636	.197400	5.065835	.9810680	50	.31	.1996530	.203755	4.907849		.9798667	29	.51	.2053502	.209821	4.765949	.9786886	9
11	.1939490	.197703	5.058090	.9810116	49	.32	.1999380	.204058	4.900562		.9798086	28	.52	.2056349	.210125	4.759060	.9786288	8
12	.1942344	.198005	5.050369	.9809552	48	.33	.2002230	.204361	4.893295		.9797504	27	.53	.2059195	.210429	4.752190	.9785689	7
13	.1945197	.198307	5.042670	.9808986	47	.34	.2005080	.204664	4.886049		.9796921	26	.54	.2062042	.210733	4.745340	.9785090	6
14	.1948050	.198610	5.034993	.9808420	46	.35	.2007930	.204967	4.878824		.9796337	25	.55	.2064888	.211036	4.738508	.9784490	5
15	.1950903	.198912	5.027339	.9807853	45	.36	.2010779	.205270	4.871620		.9795752	24	.56	.2067734	.211340	4.731695	.9783889	4
16	.1953756	.199214	5.019707	.9807285	44	.37	.2013629	.205573	4.864435		.9795167	23	.57	.2070580	.211644	4.724901	.9783287	3
17	.1956609	.199517	5.012098	.9806716	43	.38	.2016478	.205876	4.857271		.9794581	22	.58	.2073426	.211948	4.718125	.9782684	2
18	.1959461	.199819	5.004511	.9806147	42	.39	.2019327	.206180	4.850128		.9793994	21	.59	.2076272	.212252	4.711368	.9782080	1
19	.1962314	.200122	4.996945	.9805576	41	.40	.2022176	.206483	4.843004		.9793406	20	.60	.2079117	.212556	4.704630	.9781476	0
20	.1965166	.200424	4.989402	.9805005	40													
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'			

Deg. 78.

Deg. 78.

Deg. 78.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

12 Deg.

12 Deg.

12 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	2079117	212556	4704630	9781476	6021	2138829	218949	4567261	9768593	3941	2195624	225054	4443376	9755985	19
1	2081962	212860	4697910	9780871	5922	2141671	219254	4560911	9767970	3842	2198462	225359	4437350	9755345	18
2	2084807	213164	4691208	9780265	5823	2144512	219559	4554577	9767347	3743	2201300	225665	4431339	9754706	17
3	2087652	213468	4684524	9779658	5724	2147353	219864	4548260	9766723	3644	2204137	225971	4425343	9754065	16
4	2090497	213773	4677859	9779050	5625	2150194	220169	4541960	9766098	3545	2206974	226276	4419364	9753423	15
5	2093341	214077	4671212	9778441	5526	2153035	220474	4535677	9765472	3446	2209811	226582	4413399	9752781	14
6	2096186	214381	4664583	9777832	5427	2155876	220779	4529410	9764845	3347	2212648	226888	4407450	9752138	13
7	2099030	214685	4657972	9777222	5328	2158716	221084	4523160	9764217	3248	2215485	227194	4401516	9751494	12
8	2101874	214990	4651378	9776611	5229	2161556	221389	4516926	9763589	3149	2218321	227500	4395597	9750849	11
9	2104718	215294	4644803	9775999	5130	2164396	221694	4510708	9762960	3050	2221158	227806	4389694	9750203	10
10	2107561	215598	4638245	9775386	5031	2167236	221999	4504507	9762330	2951	2223994	228112	4383805	9749556	9
11	2110405	215903	4631705	9774773	4932	2170076	222305	4498322	9761699	2852	2226830	228418	4377931	9748909	8
12	2113248	216207	4625183	9774159	4833	2172915	222610	4492153	9761067	2753	2229666	228724	4372073	9748261	7
13	2116091	216512	4618678	9773544	4734	2175754	222915	4486000	9760435	2654	2232501	229030	4366229	9747612	6
14	2118934	216816	4612190	9772928	4635	2178593	223221	4479863	9759802	2555	2235337	229336	4360400	9746962	5
15	2121777	217121	4605720	9772311	4536	2181432	223526	4473742	9759168	2456	2238172	229642	4354586	9746311	4
16	2124619	217425	4599268	9771693	4437	2184271	223831	4467637	9758533	2357	2241007	229949	4348786	9745660	3
17	2127462	217730	4592832	9771075	4338	2187110	224137	4461548	9757897	2258	2243842	230255	4343001	9745008	2
18	2130304	218035	4586414	9770456	4239	2189948	224442	4455475	9757260	2159	2246676	230561	4337231	9744355	1
19	2133146	218340	4580012	9769836	4140	2192786	224748	4449418	9756623	2060	2249511	230868	4331475	9743701	0
20	2135988	218644	4573628	9769215	40										
°	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 77.

Deg. 77.

Deg. 77.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

13 Deg.

13 Deg.

13 Deg.

	Sine.	Tang.	Cotang.	Cosine.	'	'	Sine.	Tang.	Cotang.	Cosine.	'	'	Sine.	Tang.	Cotang.	Cosine.	'	'
0	.2249511	.230868	4.331475	.9743701	60	21	.2308989	.237311	4.213869	.9729777	39	41	.2365555	.243465	4.107356	.9716180	19	
1	.2252345	.231174	4.325734	.9743046	59	22	.2311819	.237618	4.208419	.9729105	38	42	.2368381	.243773	4.102164	.9715491	18	
2	.2255179	.231481	4.320007	.9742390	58	23	.2314649	.237926	4.202983	.9728432	37	43	.2371207	.244081	4.096985	.9714802	17	
3	.2258013	.231787	4.314295	.9741734	57	24	.2317479	.238233	4.197560	.9727759	36	44	.2374033	.244390	4.091817	.9714112	16	
4	.2260846	.232094	4.308597	.9741077	56	25	.2320309	.238541	4.192151	.9727084	35	45	.2376859	.244698	4.086662	.9713421	15	
5	.2263680	.232400	4.302913	.9740419	55	26	.2323138	.238848	4.186754	.9726409	34	46	.2379684	.245006	4.081519	.9712729	14	
6	.2266513	.232707	4.297244	.9739760	54	27	.2325967	.239156	4.181371	.9725733	33	47	.2382510	.245315	4.076389	.9712036	13	
7	.2269346	.233014	4.291588	.9739100	53	28	.2328796	.239463	4.176001	.9725056	32	48	.2385335	.245623	4.071270	.9711343	12	
8	.2272179	.233320	4.285947	.9738439	52	29	.2331625	.239771	4.170644	.9724378	31	49	.2388159	.245932	4.066164	.9710649	11	
9	.2275012	.233627	4.280319	.9737778	51	30	.2334454	.240078	4.165299	.9723699	30	50	.2390984	.246240	4.061070	.9709953	10	
10	.2277844	.233934	4.274706	.9737116	50	31	.2337282	.240386	4.159968	.9723020	29	51	.2393808	.246549	4.055987	.9709258	9	
11	.2280677	.234241	4.269107	.9736453	49	32	.2340110	.240694	4.154650	.9722339	28	52	.2396633	.246857	4.050917	.9708561	8	
12	.2283509	.234547	4.263521	.9735789	48	33	.2342938	.241001	4.149344	.9721658	27	53	.2399457	.247166	4.045859	.9707863	7	
13	.2286341	.234854	4.257950	.9735124	47	34	.2345766	.241309	4.144051	.9720976	26	54	.2402280	.247475	4.040812	.9707165	6	
14	.2289172	.235161	4.252392	.9734458	46	35	.2348594	.241617	4.138771	.9720294	25	55	.2405104	.247783	4.035777	.9706466	5	
15	.2292004	.235468	4.246848	.9733792	45	36	.2351421	.241925	4.133504	.9719610	24	56	.2407927	.248092	4.030755	.9705766	4	
16	.2294835	.235775	4.241317	.9733125	44	37	.2354248	.242233	4.128249	.9718926	23	57	.2410751	.248401	4.025744	.9705065	3	
17	.2297666	.236082	4.235800	.9732457	43	38	.2357075	.242541	4.123007	.9718240	22	58	.2413574	.248710	4.020744	.9704363	2	
18	.2300497	.236390	4.230297	.9731789	42	39	.2359902	.242849	4.117778	.9717554	21	59	.2416396	.249019	4.015757	.9703660	1	
19	.2303328	.236697	4.224808	.9731119	41	40	.2362729	.243157	4.112561	.9716867	20	60	.2419219	.249328	4.010780	.9702957	0	
20	.2306159	.237004	4.219331	.9730449	40													

Deg. 76.

Deg. 76.

Deg. 76.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

14 Deg.

14 Deg.

14 Deg.

/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	2419219	249328	4.010780	9702957	60	21	2478445	255826	3.908901	9687998	39	41	2534766	262034	3.816295
1	2422041	249637	4.005816	9702253	59	22	2481263	256136	3.904171	9687277	38	42	2537579	262345	3.811773
2	2424863	249946	4.000863	9701548	58	23	2484081	256446	3.899451	9686555	37	43	2540393	262656	3.807260
3	2427685	250255	3.995932	9700842	57	24	2486899	256756	3.894742	9685832	36	44	2543206	262967	3.802758
4	2430507	250564	3.990992	9700135	56	25	2489716	257066	3.890044	9685108	35	45	2546019	263278	3.798266
5	2433329	250873	3.986073	9699428	55	26	2492533	257376	3.885357	9684383	34	46	2548832	263589	3.793783
6	2436150	251182	3.981166	9698720	54	27	2495350	257686	3.880680	9683658	33	47	2551645	263900	3.789310
7	2438971	251491	3.976271	9698011	53	28	2498167	257997	3.876014	9682931	32	48	2554458	264211	3.784848
8	2441792	251801	3.971386	9697301	52	29	2500984	258307	3.871358	9682204	31	49	2557270	264522	3.780395
9	2444613	252110	3.966513	9696591	51	30	2503800	258617	3.866713	9681476	30	50	2560082	264833	3.775951
10	2447433	252420	3.961651	9695879	50	31	2506616	258928	3.862078	9680748	29	51	2562894	265145	3.771518
11	2450254	252729	3.956801	9695167	49	32	2509432	259238	3.857453	9680018	28	52	2565705	265456	3.767094
12	2453074	253038	3.951901	9694453	48	33	2512248	259548	3.852839	9679288	27	53	2568517	265768	3.762680
13	2455894	253348	3.947133	9693740	47	34	2515063	259859	3.848235	9678557	26	54	2571328	266079	3.758276
14	2458713	253658	3.942315	9693025	46	35	2517879	260169	3.843642	9677825	25	55	2574139	266390	3.753881
15	2461533	253967	3.937509	9692309	45	36	2520694	260480	3.839059	9677092	24	56	2576950	266702	3.749496
16	2464352	254277	3.932714	9691593	44	37	2523508	260791	3.834486	9676358	23	57	2579760	267014	3.745120
17	2467171	254587	3.927929	9690875	43	38	2526323	261101	3.829923	9675624	22	58	2582570	267325	3.740754
18	2469990	254896	3.923156	9690157	42	39	2529137	261412	3.825370	9674888	21	59	2585381	267637	3.736398
19	2472809	255206	3.918393	9689438	41	40	2531952	261723	3.820828	9674152	20	60	2588190	267949	3.732050
20	2475627	255516	3.913642	9688719	40										
/	Cosine.	Cotang.		Sine.	/	Cosine.	Cotang.		Sine.	/	Cosine.	Cotang.		Sine.	/

Deg. 75.

Deg. 75.

Deg. 75.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

15 Deg.

15 Deg.

15 Deg.

/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	
0	2588190	267949	3732050	9659258	60	21	2647147	3642891	9643268	39	41	2703204	280773	3561590	9627704	19
1	2591000	268261	3727713	9658505	59	22	2649952	3638744	9642497	38	42	2706004	281087	3557613	9626917	18
2	2593810	268572	3723384	9657751	58	23	2652757	3634606	9641726	37	43	2708805	281401	3553644	9626130	17
3	2596619	268884	3719065	9656996	57	24	2655561	3630477	9640954	36	44	2711605	281715	3549684	9625342	16
4	2599428	269196	3714756	9656240	56	25	2658366	3626356	9640181	35	45	2714404	282029	3545732	9624552	15
5	2602237	269508	3710455	9655484	55	26	2661170	3622244	9639407	34	46	2717204	282343	3541788	9623762	14
6	2605045	269820	3706164	9654726	54	27	2663973	3618141	9638633	33	47	2720003	282657	3537852	9622972	13
7	2607853	270132	3701883	9653968	53	28	2666777	3614046	9637858	32	48	2722802	282971	3533925	9622180	12
8	2610662	270444	3697610	9653209	52	29	2669581	3609960	9637081	31	49	2725601	283285	3530005	9621387	11
9	2613469	270757	3693346	9652449	51	30	2672384	3605883	9636305	30	50	2728400	283599	3526093	9620594	10
10	2616277	271069	3689092	9651689	50	31	2675187	3601814	9635527	29	51	2731198	283914	3522190	9619800	9
11	2619085	271381	3684847	9650927	49	32	2677989	3597754	9634748	28	52	2733997	284228	3518294	9619005	8
12	2621892	271694	3680611	9650165	48	33	2680792	3593702	9633969	27	53	2736794	284543	3514407	9618210	7
13	2624699	272006	3676384	9649402	47	34	2683594	3589659	9633189	26	54	2739592	284857	3510527	9617413	6
14	2627506	272318	3672166	9648638	46	35	2686396	3585624	9632408	25	55	2742390	285172	3506655	9616616	5
15	2630312	272631	3667957	9647873	45	36	2689198	3581597	9631626	24	56	2745187	285486	3502791	9615818	4
16	2633118	272943	3663757	9647108	44	37	2692000	3577579	9630843	23	57	2747984	285801	3498935	9615019	3
17	2635925	273256	3659566	9646341	43	38	2694801	3573569	9630060	22	58	2750781	286115	3495087	9614219	2
18	2638730	273569	3655384	9645574	42	39	2697602	3569568	9629275	21	59	2753577	286430	3491247	9613418	1
19	2641536	273881	3651211	9644806	41	40	2700403	3565574	9628490	20	60	2756374	286745	3487414	9612617	0
20	2644342	274194	3647046	9644037	40											
/	Cosine.	Cotang.	Tang.	Sine.	/	Cosine.	Cotang.	Tang.	Sine.	/	Cosine.	Cotang.	Tang.	Sine.	/	

Deg. 74.

Deg. 74.

Deg. 74.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

16 Deg.

16 Deg.

16 Deg.

	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	2756374	286745	3487414	9612617	60	21	2815042	293368	340868	39	41	2870819	299697	3336699	9579060
1	2759170	287080	3483589	9611815	59	22	2817833	293683	3405021	38	42	2873605	300014	3333173	9578225
2	2761965	287375	3479772	9611012	58	23	2820624	293999	3401361	37	43	2876391	300331	3329654	9577389
3	2764761	287690	3475963	9610208	57	24	2823415	294316	3397708	36	44	2879177	300648	3326141	9576552
4	2767556	288005	3472161	9609403	56	25	2826205	294632	3394063	35	45	2881963	300965	3322636	9575714
5	2770352	288320	3468367	9608598	55	26	2828995	294948	3390424	34	46	2884748	301283	3319137	9574875
6	2773147	288635	3464581	9607792	54	27	2831785	295264	3386793	33	47	2887533	301600	3315645	9574035
7	2775941	288950	3460802	9606984	53	28	2834575	295580	3383169	32	48	2890318	301917	3312159	9573195
8	2778736	289265	3457031	9606177	52	29	2837364	295897	3379553	31	49	2893103	302235	3308681	9572354
9	2781530	289580	3453267	9605368	51	30	2840153	296213	3375943	30	50	2895887	302552	3305209	9571512
10	2784324	289896	3449512	9604558	50	31	2842942	296529	3372340	29	51	2898671	302870	3301743	9570669
11	2787118	290211	3445763	9603748	49	32	2845731	296846	3368745	28	52	2901455	303187	3298285	9569825
12	2789911	290526	3442022	9602937	48	33	2848520	297163	3365156	27	53	2904239	303505	3294833	9568981
13	2792704	290842	3438289	9602125	47	34	2851308	297479	3361575	26	54	2907022	303823	3291387	9568136
14	2795497	291157	3434563	9601312	46	35	2854096	297796	3358000	25	55	2909805	304141	3287948	9567290
15	2798290	291473	3430844	9600499	45	36	2856884	298112	3354433	24	56	2912588	304458	3284516	9566443
16	2801083	291789	3427153	9599684	44	37	2859671	298429	3350872	23	57	2915371	304776	3281090	9565595
17	2803875	292104	3423429	9598869	43	38	2862458	298746	3347319	22	58	2918153	305094	3277671	9564747
18	2806667	292420	3419733	9598053	42	39	2865245	299063	3343772	21	59	2920935	305412	3274258	9563898
19	2809459	292736	3416044	9597236	41	40	2868032	299380	3340232	20	60	2923717	305730	3270852	9563048
20	2812251	293052	3412362	9596418	40										

Deg. 73.

Deg. 73.

Deg. 73.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

56

17 Deg.

17 Deg.

17 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	.2923717	.305730	3.270852	.95633048	60	.2982079	3.12422	3.200789	.9545009	39	.41	.3037559	3.18920	3.136563	.9527499
1	.2926499	.306048	3.267452	.9562197	59	.2984856	3.12742	3.197521	.9544141	38	.42	.3040331	3.19140	3.133414	.9526615
2	.2929280	.306367	3.264059	.9561345	58	.2987632	3.13061	3.194259	.9543273	37	.43	.3043102	3.19461	3.130270	.9525730
3	.2932061	.306685	3.260672	.9560492	57	.2990408	3.13381	3.191003	.9542403	36	.44	.3045872	3.19781	3.127131	.9524844
4	.2934842	.307003	3.257292	.9559639	56	.2993184	3.13700	3.187754	.9541533	35	.45	.3048643	3.20102	3.123989	.9523958
5	.2937623	.307321	3.253918	.9558785	55	.2995959	3.14020	3.184510	.9540662	34	.46	.3051413	3.20423	3.120872	.9523071
6	.2940403	.307640	3.250550	.9557930	54	.2998734	3.14339	3.181272	.9539790	33	.47	.3054183	3.20744	3.117750	.9522183
7	.2943183	.307958	3.247189	.9557074	53	.3001509	3.14659	3.178040	.9538917	32	.48	.3056953	3.21064	3.114635	.9521294
8	.2945963	.308277	3.243834	.9556218	52	.3004284	3.14979	3.174814	.9538044	31	.49	.3059723	3.21385	3.111525	.9520404
9	.2948743	.308595	3.240486	.9555361	51	.3007058	3.15298	3.171594	.9537170	30	.50	.3062492	3.21706	3.108421	.9519514
10	.2951522	.308914	3.237143	.9554502	50	.3009832	3.15618	3.168380	.9536294	29	.51	.3065261	3.22027	3.105322	.9518623
11	.2954302	.309233	3.233807	.9553643	49	.3012606	3.15938	3.165172	.9535418	28	.52	.3068030	3.22348	3.102229	.9517731
12	.2957081	.309551	3.230478	.9552784	48	.3015380	3.16258	3.161970	.9534542	27	.53	.3070798	3.22670	3.099141	.9516838
13	.2959859	.309870	3.227154	.9551923	47	.3018153	3.16578	3.158774	.9533664	26	.54	.3073566	3.22991	3.096059	.9515944
14	.2962638	.310189	3.223837	.9551062	46	.3020926	3.16898	3.155584	.9532786	25	.55	.3076334	3.23312	3.092983	.9515050
15	.2965416	.310508	3.220526	.9550199	45	.3023699	3.17218	3.152399	.9531907	24	.56	.3079102	3.23633	3.089912	.9514154
16	.2968194	.310827	3.217221	.9549336	44	.3026471	3.17538	3.149220	.9531027	23	.57	.3081869	3.23955	3.086846	.9513258
17	.2970971	.311146	3.213922	.9548473	43	.3029244	3.17859	3.146047	.9530146	22	.58	.3084636	3.24276	3.083796	.9512361
18	.2973749	.311465	3.210630	.9547608	42	.3032016	3.18179	3.142880	.9529264	21	.59	.3087403	3.24598	3.080732	.9511464
19	.2976526	.311784	3.207344	.9546743	41	.3034788	3.18499	3.139719	.9528382	20	.60	.3090170	3.24919	3.077683	.9510565
20	.2979303	.312103	3.204063	.9545876	40										
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 72.

Deg. 72.

Deg. 72.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

18 Deg.

18 Deg.

18 Deg.

/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	3090170	324919	3-077683	9510565	60	21	3148209	331686	3-014892						
1	3092936	325241	3-074640	9509666	59	22	3150969	332069	3-011960						
2	3095702	325563	3-071602	9508766	58	23	3153730	332332	3-009033						
3	3098468	325884	3-068569	9507865	57	24	3156490	332655	3-006110						
4	3101234	326206	3-065542	9506963	56	25	3159250	332978	3-003193						
5	3103999	326528	3-062520	9506061	55	26	3162010	333302	3-000282						
6	3106764	326850	3-059503	9505157	54	27	3164770	333625	2-997375						
7	3109529	327172	3-056492	9504253	53	28	3167529	333948	2-994473						
8	3112294	327494	3-053487	9503348	52	29	3170288	334271	2-991576						
9	3115058	327816	3-050486	9502443	51	30	3173047	334595	2-988685						
10	3117822	328138	3-047491	9501536	50	31	3175805	334918	2-985798						
11	3120586	328461	3-044501	9500629	49	32	3178563	335242	2-982916						
12	3123349	328783	3-041517	9499721	48	33	3181321	335566	2-980040						
13	3126112	329105	3-038538	9498812	47	34	3184079	335889	2-977168						
14	3128875	329428	3-035564	9497902	46	35	3186836	336213	2-974301						
15	3131638	329750	3-032595	9496991	45	36	3189593	336537	2-971439						
16	3134400	330073	3-029632	9496080	44	37	3192350	336861	2-968583						
17	3137163	330395	3-026673	9495168	43	38	3195106	337185	2-965731						
18	3139925	330718	3-023720	9494255	42	39	3197863	337509	2-962884						
19	3142686	331041	3-020772	9493341	41	40	3200619	337833	2-960042						
20	3145448	331363	3-017830	9492426	40										

Deg. 71.

D-g. 71.

Deg. 71.



## NATURAL SINES AND TANGENTS TO A RADIUS 1.

19 Deg.

19 Deg.

19 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	3255682	344327	2-904210	9455186	60	21	3313379	351175	2-847583	9435122	39	41	3368214	357723	2-795453
1	3258432	344653	2-901468	9454238	59	22	3316123	351501	2-844935	9434157	38	42	3370953	358051	2-792891
2	3261182	344978	2-898731	9453290	58	23	3318867	351828	2-842392	9433192	37	43	3373691	358380	2-790333
3	3263932	345304	2-895998	9452341	57	24	3321611	352155	2-839853	9432227	36	44	3376429	358708	2-787780
4	3266681	345629	2-893270	9451391	56	25	3324355	352482	2-837019	9431260	35	45	3379167	359036	2-785230
5	3269430	345955	2-890546	9450441	55	26	3327098	352809	2-834389	9430293	34	46	3381905	359365	2-782685
6	3272179	346281	2-887827	9449489	54	27	3329841	353136	2-831763	9429324	33	47	3384642	359693	2-780144
7	3274928	346606	2-885113	9448537	53	28	3332584	353464	2-829142	9428355	32	48	3387379	360022	2-777606
8	3277676	346932	2-882403	9447584	52	29	3335326	353791	2-826525	9427386	31	49	3390116	360350	2-775073
9	3280424	347258	2-879697	9446630	51	30	3338069	354118	2-823912	9426415	30	50	3392852	360679	2-772544
10	3283172	347584	2-876997	9445675	50	31	3340810	354446	2-821304	9425444	29	51	3395589	361008	2-770019
11	3285919	347910	2-874300	9444720	49	32	3343552	354773	2-818700	9424471	28	52	3398325	361337	2-767499
12	3288666	348236	2-871608	9443764	48	33	3346293	355100	2-816100	9423498	27	53	3401060	361666	2-764982
13	3291413	348563	2-868921	9442807	47	34	3349034	355428	2-813504	9422525	26	54	3403796	361994	2-762469
14	3294160	348889	2-866238	9441849	46	35	3351775	355756	2-810913	9421550	25	55	3406531	362324	2-759960
15	3296906	349215	2-863560	9440890	45	36	3354516	356084	2-808326	9420575	24	56	3409265	362653	2-757456
16	3299653	349542	2-860886	9439931	44	37	3357256	356411	2-805743	9419598	23	57	3412000	362982	2-754955
17	3302398	349868	2-858216	9438971	43	38	3359996	356739	2-803164	9418621	22	58	3414734	363311	2-752458
18	3305144	350195	2-855551	9438010	42	39	3362735	357067	2-800590	9417644	21	59	3417468	363640	2-749966
19	3307889	350521	2-852891	9437048	41	40	3365475	357395	2-798019	9416665	20	60	3420201	363970	2-747477
20	3310634	350848	2-850234	9436085	40										
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 70.

Deg. 70.

Deg. 70.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

20 Deg.

20 Deg.

20 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	
0	3420201	363970	2747477	9396926	60	21	3477540	370903	2696118	39	41	3532027	377536	2648753	9355468	19
1	3422935	364299	2744992	9395931	59	22	3480267	371234	2693714	38	42	3534748	377868	2646423	9354440	18
2	3425668	364629	2742512	9394935	58	23	3482994	371565	2691314	37	43	3537469	378201	2644096	9353412	17
3	3428400	364958	2740035	9393938	57	24	3485720	371896	2688919	36	44	3540190	378533	2641774	9352382	16
4	3431133	365288	2737562	9392940	56	25	3488447	372227	2686526	35	45	3542910	378866	2639454	9351352	15
5	3433865	365618	2735093	9391942	55	26	3491173	372559	2684138	34	46	3545630	379198	2637139	9350321	14
6	3436597	365948	2732628	9390943	54	27	3493898	372890	2681753	33	47	3548350	379531	2634827	9349289	13
7	3439329	366277	2730167	9389943	53	28	3496624	373221	2679372	32	48	3551070	379864	2632518	9348257	12
8	3442060	366607	2727710	9388942	52	29	3499349	373553	2676995	31	49	3553789	380197	2630213	9347223	11
9	3444791	366937	2725256	9387940	51	30	3502074	373884	2674621	30	50	3556508	380530	2627912	9346189	10
10	3447521	367268	2722807	9386938	50	31	3504798	374216	2672251	29	51	3559226	380863	2625614	9345154	9
11	3450252	367598	2720362	9385934	49	32	3507523	374547	2669885	28	52	3561944	381196	2623319	9344119	8
12	3452982	367928	2717920	9384930	48	33	3510246	374879	2667522	27	53	3564662	381529	2621028	9343082	7
13	3455712	368258	2715482	9383925	47	34	3512970	375211	2665163	26	54	3567380	381862	2618741	9342045	6
14	3458441	368589	2713048	9382920	46	35	3515693	375543	2662808	25	55	3570097	382196	2616457	9341007	5
15	3461171	368919	2710618	9381913	45	36	3518416	375875	2660456	24	56	3572814	382529	2614176	9339968	4
16	3463900	369250	2708192	9380906	44	37	3521139	376207	2658108	23	57	3575531	382863	2611899	9338928	3
17	3466628	369580	2705769	9379898	43	38	3523862	376539	2655764	22	58	3578248	383196	2609625	9337888	2
18	3469357	369911	2703351	9378889	42	39	3526584	376871	2653423	21	59	3580964	383530	2607355	9336846	1
19	3472085	370242	2700936	9377880	41	40	3529306	377203	2651086	20	60	3583679	383864	2605089	9335804	0
20	3474812	370572	2698525	9376869	40											
°	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	

Deg. 69.

Deg. 69.

Deg. 69.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

21 Deg.

21 Deg.

21 Deg.

	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	3583679	383864	2.605089	9335804	60	21	3640641	390389	2.558268	9313739	39	41	3694765	397611	2.515018
1	3586395	384197	2.602825	9334761	59	22	3643351	391224	2.556075	9312679	38	42	3697468	397948	2.512889
2	3589110	384531	2.600565	9333718	58	23	3646059	391560	2.553885	9311619	37	43	3700170	398285	2.510762
3	3591825	384865	2.598309	9332673	57	24	3648768	391895	2.551699	9310558	36	44	3702872	398622	2.508639
4	3594540	385199	2.596056	9331628	56	25	3651476	392231	2.549516	9309496	35	45	3705574	398959	2.506519
5	3597254	385533	2.593806	9330582	55	26	3654184	392567	2.547335	9308434	34	46	3708276	399296	2.504402
6	3599968	385867	2.591560	9329535	54	27	3656891	392902	2.545159	9307370	33	47	3710977	399634	2.502289
7	3602682	386202	2.589317	9328488	53	28	3659599	393238	2.542985	9306306	32	48	3713678	399971	2.500178
8	3605395	386536	2.587078	9327439	52	29	3662306	393574	2.540815	9305241	31	49	3716379	400308	2.498070
9	3608108	386870	2.584842	9326390	51	30	3665012	393910	2.538647	9304176	30	50	3719079	400646	2.495966
10	3610821	387205	2.582609	9325340	50	31	3667719	394246	2.536483	9303109	29	51	3721780	400984	2.493864
11	3613534	387539	2.580380	9324290	49	32	3670425	394582	2.534323	9302042	28	52	3724479	401321	2.491766
12	3616246	387874	2.578153	9323238	48	33	3673130	394918	2.532165	9300974	27	53	3727179	401659	2.489670
13	3618958	388209	2.575931	9322186	47	34	3675836	395255	2.530011	9299905	26	54	3729878	401997	2.487578
14	3621669	388543	2.573711	9321133	46	35	3678541	395591	2.527859	9298835	25	55	3732577	402335	2.485488
15	3624380	388878	2.571495	9320079	45	36	3681246	395928	2.525711	9297765	24	56	3735275	402673	2.483402
16	3627091	389213	2.569283	9319024	44	37	3683950	396264	2.523566	9296694	23	57	3737973	403011	2.481319
17	3629802	389548	2.567073	9317969	43	38	3686654	396601	2.521424	9295622	22	58	3740671	403349	2.479238
18	3632512	389883	2.564867	9316912	42	39	3689358	396937	2.519286	9294549	21	59	3743369	403687	2.477161
19	3635222	390218	2.562664	9315855	41	40	3692061	397274	2.517150	9293475	20	60	3746066	404026	2.475086
20	3637932	390554	2.560464	9314797	40										
	Cosine.	Cotang.	Tang.	Sine.	'		Cosine.	Cotang.	Tang.	Sine.	'		Cosine.	Cotang.	Sine.

Deg. 68.

Deg. 68.

Deg. 68.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

22 Deg.

22 Deg.

22 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	
0	3746066	404026	2.475086	9271839	60	21	3802634	411149	2.432204	9248782	39	41	3856377	417967	2.392531	9226503
1	3748763	404364	2.473015	9270748	59	22	3805324	411489	2.430193	9247676	38	42	3859060	418309	2.390576	9225381
2	3751459	404703	2.470947	9269658	58	23	3808014	411830	2.428186	9246568	37	43	3861744	418650	2.388625	9224258
3	3754156	405041	2.468881	9268566	57	24	3810704	412170	2.426181	9245460	36	44	3864427	418992	2.386675	9223134
4	3756852	405380	2.466819	9267474	56	25	3813393	412510	2.424180	9244351	35	45	3867110	419334	2.384729	9222010
5	3759547	405719	2.464759	9266380	55	26	3816082	412851	2.422181	9243242	34	46	3869792	419676	2.382785	9220884
6	3762243	406057	2.462703	9265286	54	27	3818770	413191	2.420185	9242131	33	47	3872474	420019	2.380844	9219758
7	3764938	406396	2.460649	9264192	53	28	3821459	413532	2.418191	9241020	32	48	3875156	420361	2.378906	9218632
8	3767632	406735	2.458598	9263096	52	29	3824147	413872	2.416201	9239908	31	49	3877837	420703	2.376970	9217504
9	3770327	407074	2.456551	9262000	51	30	3826834	414213	2.414213	9238795	30	50	3880518	421046	2.375037	9216375
10	3773021	407413	2.454506	9260902	50	31	3829522	414554	2.412228	9237682	29	51	3883199	421388	2.373106	9215246
11	3775714	407753	2.452464	9259805	49	32	3832209	414895	2.410246	9236567	28	52	3885880	421731	2.371179	9214116
12	3778408	408092	2.450425	9258706	48	33	3834895	415236	2.408267	9235452	27	53	3888560	422073	2.369254	9212986
13	3781101	408431	2.448389	9257606	47	34	3837582	415577	2.406290	9234336	26	54	3891240	422416	2.367331	9211854
14	3783794	408771	2.446355	9256506	46	35	3840268	415918	2.404316	9233220	25	55	3893919	422759	2.365411	9210722
15	3786486	409110	2.444325	9255405	45	36	3842953	416259	2.402345	9232102	24	56	3896598	423102	2.363494	9209589
16	3789178	409450	2.442298	9254303	44	37	3845639	416601	2.400377	9230984	23	57	3899277	423445	2.361580	9208455
17	3791870	409790	2.440273	9253201	43	38	3848324	416942	2.398411	9229865	22	58	3901955	423788	2.359668	9207320
18	3794562	410129	2.438251	9252097	42	39	3851008	417284	2.396449	9228745	21	59	3904633	424131	2.357759	9206185
19	3797253	410469	2.436233	9250993	41	40	3853693	417625	2.394488	9227624	20	60	3907311	424474	2.355852	9205049
20	3799944	410809	2.434217	9249888	40											
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	

Deg. 67.

Deg. 67.

Deg. 67.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

23 Deg.

23 Deg.

23 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	3907311	424474	2-355852	9205049	60	21	3963468	431703	2-316107	39	41	4016814	438622	2-279865	9157795
1	3909989	424818	2-353948	9203912	59	22	3966139	432048	2-314557	38	42	4019478	438969	2-278063	9156626
2	3912666	425161	2-352046	9202774	58	23	3968809	432393	2-312709	37	43	4022141	439316	2-276264	9155456
3	3915343	425505	2-350148	9201635	57	24	3971479	432738	2-310863	36	44	4024804	439663	2-274467	9154286
4	3918019	425848	2-348251	9200496	56	25	3974148	433084	2-309020	35	45	4027467	440010	2-272672	9153115
5	3920695	426192	2-346358	9199356	55	26	3976818	433429	2-307180	34	46	4030129	440357	2-270880	9151943
6	3923371	426536	2-344467	9198215	54	27	3979486	433775	2-305342	33	47	4032791	440705	2-269090	9150770
7	3926047	426880	2-342578	9197073	53	28	3982155	434120	2-303506	32	48	4035453	441052	2-267303	9149597
8	3928722	427223	2-340692	9195931	52	29	3984823	434466	2-301673	31	49	4038114	441400	2-265518	9148422
9	3931397	427568	2-338809	9194788	51	30	3987491	434812	2-299842	30	50	4040775	441747	2-263735	9147247
10	3934071	427912	2-336928	9193644	50	31	3990158	435158	2-298014	29	51	4043436	442095	2-261955	9146072
11	3936745	428256	2-335050	9192499	49	32	3992825	435504	2-296188	28	52	4046096	442443	2-260177	9144895
12	3939419	428600	2-333174	9191353	48	33	3995492	435850	2-294365	27	53	4048756	442791	2-258401	9143718
13	3942093	428944	2-331301	9190207	47	34	3998158	436196	2-292544	26	54	4051416	443139	2-256628	9142540
14	3944766	429289	2-329431	9189060	46	35	4000825	436542	2-290725	25	55	4054075	443487	2-254857	9141361
15	3947439	429633	2-327563	9187912	45	36	4003490	436889	2-288909	24	56	4056734	443835	2-253088	9140181
16	3950111	429978	2-325697	9186763	44	37	4006156	437235	2-287095	23	57	4059393	444183	2-251322	9139001
17	3952783	430323	2-323834	9185614	43	38	4008821	437582	2-285284	22	58	4062051	444531	2-249558	9137819
18	3955455	430668	2-321974	9184464	42	39	4011486	437928	2-283475	21	59	4064709	444880	2-247796	9136637
19	3958127	431012	2-320116	9183313	41	40	4014150	438275	2-281669	20	60	4067366	445228	2-246036	9135455
20	3960798	431357	2-318260	9182161	40										

Deg. 66.

Deg. 66.

Deg. 66.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

24 Deg.

24 Deg.

24 Deg.

	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	4067366	445228	2-246036	9135455	60	21	4123096	452568	2-209611	9110438	39	41	4176028	459596	2-175822
1	4070024	445577	2-244279	9134271	59	22	4125745	452918	2-207901	9109238	38	42	4178671	459948	2-174155
2	4072681	445926	2-242524	9133087	58	23	4128395	453269	2-206193	9108038	37	43	4181313	460301	2-172491
3	4075337	446274	2-240772	9131902	57	24	4131044	453620	2-204487	9106837	36	44	4183956	460653	2-170828
4	4077993	446623	2-239021	9130716	56	25	4133693	453970	2-202784	9105635	35	45	4186597	461006	2-169107
5	4080649	446972	2-237273	9129529	55	26	4136342	454321	2-201083	9104432	34	46	4189239	461359	2-167509
6	4083305	447321	2-235528	9128342	54	27	4138990	454672	2-199384	9103228	33	47	4191880	461711	2-165852
7	4085960	447670	2-233784	9127154	53	28	4141638	455023	2-197687	9102024	32	48	4194521	462064	2-164198
8	4088615	448020	2-232043	9125965	52	29	4144285	455375	2-195992	9100819	31	49	4197161	462417	2-162546
9	4091269	448369	2-230304	9124775	51	30	4146932	455726	2-194299	9099613	30	50	4199801	462771	2-160895
10	4093923	448718	2-228567	9123584	50	31	4149579	456077	2-192609	9098406	29	51	4202441	463124	2-159247
11	4096577	449068	2-226833	9122393	49	32	4152226	456429	2-190921	9097199	28	52	4205080	463477	2-157601
12	4099230	449417	2-225100	9121201	48	33	4154872	456780	2-189234	9095990	27	53	4207719	463831	2-155957
13	4101883	449767	2-223370	9120008	47	34	4157517	457132	2-187551	9094781	26	54	4210358	464184	2-154315
14	4104536	450117	2-221643	9118815	46	35	4160163	457483	2-185869	9093572	25	55	4212966	464538	2-152675
15	4107189	450467	2-219917	9117620	45	36	4162808	457835	2-184189	9092361	24	56	4215634	464891	2-151037
16	4109841	450817	2-218194	9116425	44	37	4165453	458187	2-182511	9091150	23	57	4218272	465245	2-149402
17	4112492	451167	2-216473	9115229	43	38	4168097	458539	2-180836	9089938	22	58	4220909	465599	2-147768
18	4115144	451517	2-214751	9114033	42	39	4170741	458891	2-179163	9088725	21	59	4223546	465953	2-146136
19	4117795	451867	2-213037	9112835	41	40	4173385	459243	2-177492	9087511	20	60	4226183	466307	2-144506
20	4120445	452217	2-211323	9111637	40										2-142875
	Cosine.	Cotang.	Tang.	Sine.	/	Cosine.	Cotang.	Tang.	Sine.	/	Cosine.	Cotang.	Tang.	Sine.	/

Deg. 65.

Deg. 65.

Deg. 65.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

25 Deg.

25 Deg.

25 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'		
0	4226183	466307	2.144506	9063078	60	21	4281467	473765	2.110747	9037093	39	41	4333970	480909	2.079394	9012031	19
1	4228819	466661	2.142879	9061848	59	22	4284095	474122	2.109161	9035847	38	42	4336591	481267	2.077846	9010770	18
2	4231455	467016	2.141253	9060618	58	23	4286723	474478	2.107577	9034600	37	43	4339212	481625	2.076300	9009508	17
3	4234090	467370	2.139630	9059386	57	24	4289351	474834	2.105995	9033353	36	44	4341832	481984	2.074756	9008246	16
4	4236725	467725	2.138008	9058154	56	25	4291979	475191	2.104415	9032105	35	45	4344453	482342	2.073214	9006982	15
5	4239360	468079	2.136389	9056922	55	26	4294606	475548	2.102836	9030856	34	46	4347072	482701	2.071674	9005718	14
6	4241994	468434	2.134771	9055688	54	27	4297233	475904	2.101260	9029606	33	47	4349692	483060	2.070135	9004453	13
7	4244628	468789	2.133155	9054454	53	28	4299859	476261	2.099686	9028356	32	48	4352311	483418	2.068599	9003188	12
8	4247262	469143	2.131542	9053219	52	29	4302485	476618	2.098114	9027105	31	49	4354930	483777	2.067064	9001921	11
9	4249895	469498	2.129930	9051983	51	30	4305111	476975	2.096543	9025853	30	50	4357548	484136	2.065531	9000654	10
10	4252528	469853	2.128321	9050746	50	31	4307736	477332	2.094975	9024600	29	51	4360166	484495	2.064000	8999386	9
11	4255161	470209	2.126713	9049509	49	32	4310361	477689	2.093408	9023347	28	52	4362784	484855	2.062471	8998117	8
12	4257793	470564	2.125108	9048271	48	33	4312986	478047	2.091843	9022092	27	53	4365401	485214	2.060944	8996848	7
13	4260425	470919	2.123504	9047032	47	34	4315610	478404	2.090280	9020838	26	54	4368018	485573	2.059418	8995578	6
14	4263056	471275	2.121903	9045792	46	35	4318234	478762	2.088720	9019582	25	55	4370634	485933	2.057895	8994307	5
15	4265687	471630	2.120303	9044551	45	36	4320857	479119	2.087161	9018325	24	56	4373251	486293	2.056373	8993035	4
16	4268318	471986	2.118705	9043310	44	37	4323481	479477	2.085603	9017068	23	57	4375866	486652	2.054853	8991763	3
17	4270949	472342	2.117110	9042068	43	38	4326103	479835	2.084048	9015810	22	58	4378482	487012	2.053334	8990489	2
18	4273579	472697	2.115516	9040825	42	39	4328726	480193	2.082495	9014551	21	59	4381097	487372	2.051818	8989215	1
19	4276208	473053	2.113924	9039582	41	40	4331348	480551	2.080943	9013292	20	60	4383711	487732	2.050303	8987940	0
20	4278838	473409	2.112334	9038338	40												
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'		

Deg. 64.

Deg. 64.

Deg. 64.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

26 Deg.

26 Deg.

26 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	4383711	487732	2-050303	8987940	60	21	4438534	495317	2-018908	8960994	39	11	4490591	502583	1-989720
1	4386326	488092	2-048791	8986665	59	22	4441140	495679	2-017433	8959703	38	12	4493190	502947	1-988278
2	4388940	488453	2-047280	8985389	58	23	4443746	496041	2-015959	8958411	37	13	4495789	503312	1-986838
3	4391553	488813	2-045770	8984112	57	24	4446352	496404	2-014486	8957118	36	14	4498387	503676	1-985400
4	4394166	489173	2-044263	8982834	56	25	4448957	496766	2-013016	8955824	35	15	4500984	504041	1-983963
5	4396779	489534	2-042757	8981555	55	26	4451562	497129	2-011547	8954529	34	16	4503582	504406	1-982528
6	4399392	489894	2-041254	8980276	54	27	4454167	497492	2-010080	8953234	33	17	4506179	504771	1-981095
7	4402004	490255	2-039751	8978996	53	28	4456771	497855	2-008615	8951938	32	18	4508775	505136	1-979663
8	4404615	490616	2-038251	8977715	52	29	4459375	498218	2-007151	8950641	31	19	4511372	505501	1-978233
9	4407227	490977	2-036753	8976433	51	30	4461978	498581	2-005689	8949344	30	50	4513967	505866	1-976805
10	4409838	491338	2-035256	8975151	50	31	4464581	498944	2-004229	8948045	29	51	4516563	506232	1-975378
11	4412448	491699	2-033761	8973868	49	32	4467184	499308	2-002771	8946746	28	52	4519158	506597	1-973953
12	4415059	492061	2-032268	8972584	48	33	4469786	499671	2-001314	8945446	27	53	4521753	506963	1-972529
13	4417668	492422	2-030776	8971299	47	34	4472388	500035	1-999859	8944146	26	54	4524347	507329	1-971107
14	4420278	492783	2-029287	8970014	46	35	4474990	500398	1-998405	8942844	25	55	4526941	507694	1-969687
15	4422887	493145	2-027799	8968727	45	36	4477591	500762	1-996953	8941542	24	56	4529535	508060	1-968268
16	4425496	493507	2-026313	8967440	44	37	4480192	501126	1-995503	8940240	23	57	4532128	508426	1-966851
17	4428104	493868	2-024828	8966153	43	38	4482792	501490	1-994055	8938936	22	58	4534721	508792	1-965436
18	4430712	494230	2-023346	8964864	42	39	4485392	501854	1-992608	8937632	21	59	4537313	509159	1-964022
19	4433319	494592	2-021865	8963575	41	40	4487992	502218	1-991163	8936326	20	60	4539905	509525	1-962610
20	4435927	494954	2-020386	8962285	40										

Deg. 63.

Deg. 63.

Deg. 63.



# NATURAL SINES AND TANGENTS TO A RADIUS 1.

27 Deg.

27 Deg.

27 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	4539905	509525	1.962610	8910065	60	21	4594248	517244	1.933323	8882166	39	41	4645845	1.906066	8855288
1	4542497	509891	1.961200	8908744	59	22	4596832	517612	1.931945	8880830	38	42	4648420	1.904719	8853936
2	4545088	510258	1.959791	8907423	58	23	4599415	517981	1.930569	8879492	37	43	4650996	1.903373	8852584
3	4547679	510625	1.958383	8906100	57	24	4601998	518350	1.929195	8878154	36	44	4653571	1.902029	8851230
4	4550269	510991	1.956978	8904777	56	25	4604580	518719	1.927822	8876815	35	45	4656145	1.900687	8849876
5	4552859	511358	1.955573	8903453	55	26	4607162	519089	1.926451	8875475	34	46	4658719	1.899346	8848522
6	4555449	511725	1.954171	8902128	54	27	4609744	519458	1.925081	8874134	33	47	4661293	1.898006	8847166
7	4558038	512093	1.952770	8900803	53	28	4612325	519827	1.923713	8872793	32	48	4663866	1.896668	8845810
8	4560627	512460	1.951371	8899476	52	29	4614906	520197	1.922347	8871451	31	49	4666439	1.895332	8844453
9	4563216	512827	1.949973	8898149	51	30	4617486	520567	1.920982	8870108	30	50	4669012	1.893997	8843095
10	4565804	513195	1.948577	8896822	50	31	4620066	520936	1.919618	8868765	29	51	4671584	1.892663	8841736
11	4568392	513562	1.947182	8895493	49	32	4622646	521306	1.918256	8867420	28	52	4674156	1.891331	8840377
12	4570979	513930	1.945789	8894164	48	33	4625225	521676	1.916896	8866075	27	53	4676727	1.890000	8839017
13	4573566	514298	1.944398	8892834	47	34	4627804	522046	1.915537	8864730	26	54	4679298	1.888671	8837656
14	4576153	514665	1.943008	8891503	46	35	4630382	522417	1.914179	8863383	25	55	4681869	1.887343	8836295
15	4578739	515033	1.941620	8890171	45	36	4632960	522787	1.912823	8862036	24	56	4684439	1.886017	8834933
16	4581325	515401	1.940233	8888839	44	37	4635538	523157	1.911469	8860688	23	57	4687009	1.884692	8833569
17	4583910	515770	1.938848	8887506	43	38	4638115	523528	1.910116	8859339	22	58	4689578	1.883369	8832206
18	4586496	516138	1.937464	8886172	42	39	4640692	523899	1.908764	8857989	21	59	4692147	1.882047	8830841
19	4589080	516506	1.936082	8884838	41	40	4643269	524269	1.907414	8856639	20	60	4694716	1.880726	8829476
20	4591665	516875	1.934702	8883503	40										

Deg. 62.

Deg. 62.

Deg. 63

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

28 Deg.

28 Deg.

28 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'		
0	4694716	531709	1880726	8829476	60	21	4748564	539570	1853325	8800633	39	41	4799683	547106	1827799	8772858	19
1	4697284	532082	1879407	8828110	59	22	4751124	539946	1852035	8799251	38	42	4802235	547484	1826537	8771462	18
2	4699852	532455	1878098	8826743	58	23	4753683	540322	1850747	8797869	37	43	4804786	547862	1825276	8770064	17
3	4702419	532829	1876773	8825376	57	24	4756242	540698	1849461	8796486	36	44	4807337	548240	1824017	8768666	16
4	4704986	533202	1875458	8824007	56	25	4758801	541074	1848176	8795102	35	45	4809888	548618	1822759	8767268	15
5	4707553	533576	1874145	8822638	55	26	4761359	541450	1846892	8793717	34	46	4812438	548997	1821502	8765868	14
6	4710119	533950	1872833	8821269	54	27	4763917	541826	1845609	8792332	33	47	4814987	549375	1820247	8764468	13
7	4712685	534324	1871523	8819898	53	28	4766474	542202	1844328	8790946	32	48	4817537	549754	1818993	8763067	12
8	4715250	534698	1870214	8818527	52	29	4769031	542579	1843049	8789559	31	49	4820086	550133	1817740	8761665	11
9	4717815	535072	1868906	8817155	51	30	4771588	542955	1841770	8788171	30	50	4822634	550512	1816489	8760263	10
10	4720380	535446	1867600	8815782	50	31	4774144	543332	1840494	8786783	29	51	4825182	550891	1815239	8758859	9
11	4722944	535820	1866295	8814409	49	32	4776700	543709	1839218	8785394	28	52	4827730	551270	1813990	8757455	8
12	4725508	536195	1864992	8813035	48	33	4779255	544086	1837944	8784001	27	53	4830277	551650	1812743	8756051	7
13	4728071	536569	1863690	8811660	47	34	4781810	544463	1836671	8782613	26	54	4832824	552029	1811496	8754645	6
14	4730634	536944	1862389	8810284	46	35	4784364	544840	1835399	8781222	25	55	4835370	552409	1810252	8753239	5
15	4733197	537319	1861090	8808907	45	36	4786919	545217	1834129	8779830	24	56	4837916	552789	1809008	8751832	4
16	4735759	537694	1859792	8807530	44	37	4789472	545595	1832861	8778437	23	57	4840462	553168	1807766	8750425	3
17	4738321	538069	1858496	8806152	43	38	4792026	545972	1831593	8777043	22	58	4843007	553548	1806525	8749016	2
18	4740882	538444	1857201	8804774	42	39	4794579	546350	1830327	8775649	21	59	4845552	553928	1805286	8747607	1
19	4743443	538819	1855908	8803394	41	40	4797131	546728	1829062	8774254	20	60	4848096	554309	1804047	8746197	0
20	4746004	539195	1854615	8802014	40												
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'		

Deg. 61.

Deg. 61.

Deg. 61.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

29 Deg.

29 Deg.

29 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	.4848096	.554309	1.804047	.8746197	60	.21	.4901433	.562321	1.778340	39	.41	.4952060	.570004	1.754372	8687756
1	.4850640	.554689	1.802810	.8744786	59	.22	.4903968	.562704	1.777130	38	.42	.4954587	.570389	1.753186	8686315
2	.4853184	.555069	1.801575	.8743375	58	.23	.4906503	.563087	1.775921	37	.43	.4957113	.570775	1.752002	8684874
3	.4855727	.555450	1.800340	.8741963	57	.24	.4909038	.563471	1.774714	36	.44	.4959639	.571161	1.750819	8683431
4	.4858270	.555831	1.799107	.8740550	56	.25	.4911572	.563854	1.773507	35	.45	.4962165	.571547	1.749637	8681988
5	.4860812	.556211	1.797875	.8739137	55	.26	.4914105	.564237	1.772302	34	.46	.4964690	.571933	1.748456	8680544
6	.4863354	.556592	1.796645	.8737722	54	.27	.4916638	.564621	1.771098	33	.47	.4967215	.572319	1.747276	8679100
7	.4865895	.556973	1.795416	.8736307	53	.28	.4919171	.565005	1.769895	32	.48	.4969740	.572705	1.746098	8677655
8	.4868436	.557355	1.794188	.8734891	52	.29	.4921704	.565388	1.768694	31	.49	.4972264	.573091	1.744921	8676209
9	.4870977	.557736	1.792961	.8733475	51	.30	.4924236	.565772	1.767494	30	.50	.4974787	.573478	1.743745	8674762
10	.4873517	.558117	1.791736	.8732058	50	.31	.4926767	.566156	1.766295	29	.51	.4977310	.573864	1.742570	8673314
11	.4876057	.558499	1.790512	.8730640	49	.32	.4929298	.566541	1.765097	28	.52	.4979833	.574251	1.741396	8671866
12	.4878597	.558881	1.789289	.8729221	48	.33	.4931829	.566925	1.763900	27	.53	.4982355	.574638	1.740224	8670417
13	.4881136	.559262	1.788067	.8727801	47	.34	.4934359	.567309	1.762705	26	.54	.4984877	.575025	1.739053	8668967
14	.4883674	.559644	1.786847	.8726381	46	.35	.4936889	.567694	1.761511	25	.55	.4987399	.575412	1.737883	8667517
15	.4886212	.560026	1.785628	.8724960	45	.36	.4939419	.568079	1.760318	24	.56	.4989920	.575799	1.736714	8666066
16	.4888750	.560409	1.784410	.8723538	44	.37	.4941948	.568463	1.759126	23	.57	.4992441	.576187	1.735546	8664614
17	.4891288	.560791	1.783194	.8722116	43	.38	.4944476	.568848	1.757936	22	.58	.4994961	.576574	1.734380	8663161
18	.4893825	.561173	1.781979	.8720693	42	.39	.4947005	.569233	1.756747	21	.59	.4997481	.576962	1.733214	8661708
19	.4896361	.561556	1.780765	.8719269	41	.40	.4949532	.569619	1.755559	20	.60	.5000000	.577350	1.732050	8660254
20	.4898897	.561939	1.779552	.8717844	40										
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 60.

Deg. 60.

Deg. 60.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

30 Deg.

30 Deg.

30 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'		
0	5000000	577350	1.732050	8660254	60	21	5052809	585524	1.707871	8629549	39	41	5102928	593363	1.685308	8600007	19
1	5002519	577738	1.730887	8658799	59	22	5055319	585914	1.706732	8628079	38	42	5105429	593756	1.684191	8598523	18
2	5005037	578126	1.729726	8657344	58	23	5057828	586305	1.705595	8626608	37	43	5107930	594150	1.683076	8597037	17
3	5007556	578514	1.728565	8655887	57	24	5060338	586696	1.704458	8625137	36	44	5110431	594543	1.681962	8595551	16
4	5010073	578902	1.727406	8654430	56	25	5062846	587087	1.703323	8623664	35	45	5112931	594937	1.680848	8594064	15
5	5012591	579291	1.726247	8652973	55	26	5065355	587478	1.702189	8622191	34	46	5115431	595331	1.679736	8592576	14
6	5015107	579679	1.725090	8651514	54	27	5067863	587870	1.701055	8620717	33	47	5117930	595725	1.678625	8591088	13
7	5017624	580068	1.723934	8650055	53	28	5070370	588261	1.699923	8619243	32	48	5120429	596119	1.677515	8589599	12
8	5020140	580457	1.722779	8648595	52	29	5072877	588653	1.698792	8617768	31	49	5122927	596514	1.676406	8588109	11
9	5022655	580846	1.721626	8647134	51	30	5075384	589045	1.697663	8616292	30	50	5125425	596908	1.675298	8586619	10
10	5025170	581235	1.720473	8645673	50	31	5077890	589436	1.696534	8614815	29	51	5127923	597303	1.674192	8585127	9
11	5027685	581624	1.719322	8644211	49	32	5080396	589828	1.695406	8613337	28	52	5130420	597697	1.673086	8583635	8
12	5030199	582013	1.718172	8642748	48	33	5082901	590221	1.694280	8611859	27	53	5132916	598092	1.671981	8582143	7
13	5032713	582403	1.717023	8641284	47	34	5085406	590613	1.693155	8610380	26	54	5135413	598487	1.670878	8580649	6
14	5035227	582793	1.715875	8639820	46	35	5087910	591005	1.692030	8608901	25	55	5137908	598882	1.669775	8579155	5
15	5037740	583182	1.714728	8638355	45	36	5090414	591398	1.690907	8607420	24	56	5140404	599278	1.668674	8577660	4
16	5040252	583572	1.713582	8636889	44	37	5092918	591791	1.689785	8605939	23	57	5142899	599673	1.667574	8576164	3
17	5042765	583962	1.712438	8635423	43	38	5095421	592183	1.688664	8604457	22	58	5145393	600069	1.666474	8574668	2
18	5045276	584352	1.711294	8633956	42	39	5097924	592576	1.687544	8602975	21	59	5147887	600464	1.665376	8573171	1
19	5047788	584743	1.710152	8632488	41	40	5100426	592969	1.686426	8601491	20	60	5150381	600860	1.664279	8571673	0
20	5050298	585133	1.709011	8631019	40												
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'		

Deg. 59.

Deg. 59.

Deg. 59.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

31 Deg.

31 Deg.

31 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'		
0	5150381	600860	1.664279	8571673	60	21	5202646	609205	1.641482	8540051	39	41	5252241	617210	1.620192	8509639	19
1	5152874	601256	1.663183	8570174	59	22	5205130	609604	1.640408	8538538	38	42	5254717	617612	1.619138	8508111	18
2	5155367	601652	1.662088	8568675	58	23	5207613	610003	1.639335	8537023	37	43	5257191	618014	1.618055	8506582	17
3	5157859	602049	1.660994	8567175	57	24	5210096	610402	1.638263	8535508	36	44	5259665	618416	1.617033	8505053	16
4	5160351	602445	1.659901	8565674	56	25	5212579	610801	1.637191	8533992	35	45	5262139	618818	1.615982	8503522	15
5	5162842	602841	1.658809	8564173	55	26	5215061	611201	1.636121	8532475	34	46	5264613	619221	1.614932	8501991	14
6	5165333	603238	1.657718	8562671	54	27	5217543	611601	1.635052	8530958	33	47	5267085	619623	1.613982	8500459	13
7	5167824	603635	1.656629	8561168	53	28	5220024	612000	1.633984	8529440	32	48	5269558	620026	1.612934	8498927	12
8	5170314	604032	1.655540	8559664	52	29	5222505	612400	1.632917	8527921	31	49	5272030	620429	1.611787	8497394	11
9	5172804	604429	1.654452	8558160	51	30	5224986	612800	1.631851	8526402	30	50	5274502	620832	1.610741	8495860	10
10	5175293	604826	1.653366	8556655	50	31	5227466	613201	1.630786	8524981	29	51	5276973	621235	1.609696	8494325	9
11	5177782	605224	1.652280	8555149	49	32	5229945	613601	1.629722	8523360	28	52	5279443	621638	1.608652	8492790	8
12	5180270	605621	1.651196	8553643	48	33	5232424	614001	1.628659	8521839	27	53	5281914	622041	1.607609	8491254	7
13	5182758	606019	1.650112	8552135	47	34	5234903	614402	1.627597	8520316	26	54	5284383	622445	1.606567	8489717	6
14	5185246	606417	1.649030	8550627	46	35	5237381	614803	1.626536	8518793	25	55	5286853	622848	1.605526	8488179	5
15	5187733	606814	1.647949	8549119	45	36	5239859	615204	1.625476	8517269	24	56	5289322	623252	1.604485	8486641	4
16	5190219	607213	1.646868	8547609	44	37	5242336	615605	1.624417	8515745	23	57	5291790	623656	1.603446	8485102	3
17	5192705	607611	1.645789	8546099	43	38	5244813	616006	1.623359	8514219	22	58	5294258	624060	1.602409	8483562	2
18	5195191	608009	1.644711	8544588	42	39	5247290	616407	1.622302	8512693	21	59	5296726	624465	1.601370	8482022	1
19	5197676	608408	1.643633	8543077	41	40	5249766	616809	1.621246	8511167	20	60	5299193	624869	1.600334	8480481	0
20	5200161	608806	1.642557	8541564	40												
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'		

Deg. 58.

Deg. 58.

Deg. 58.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

32 Deg.

32 Deg.

32 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	5299193	624869	1.600334	8490481	60	21	5350898	633395	1.578791	8447952	39	41	5399955	641577	1.558657
1	5301659	625273	1.599299	8478939	59	22	5353355	633803	1.577776	8446395	38	42	5402403	641988	1.557660
2	5304125	625678	1.598264	8477397	58	23	5355812	634211	1.576761	8444838	37	43	5404851	642399	1.556663
3	5306591	626083	1.597231	8475853	57	24	5358268	634619	1.575747	8443279	36	44	5407298	642810	1.555668
4	5309057	626488	1.596198	8474309	56	25	5360724	635027	1.574735	8441720	35	45	5409745	643221	1.554674
5	5311521	626893	1.595167	8472765	55	26	5363179	635435	1.573723	8440161	34	46	5412191	643632	1.553680
6	5313986	627298	1.594136	8471219	54	27	5365634	635844	1.572712	8438600	33	47	5414637	644044	1.552688
7	5316450	627704	1.593107	8469673	53	28	5368089	636252	1.571702	8437039	32	48	5417082	644456	1.551696
8	5318913	628109	1.592078	8468126	52	29	5370543	636661	1.570693	8435477	31	49	5419527	644867	1.550705
9	5321376	628515	1.591050	8466579	51	30	5372996	637070	1.569685	8433914	30	50	5421971	645279	1.549715
10	5323839	628921	1.590023	8465030	50	31	5375449	637479	1.568678	8432351	29	51	5424415	645691	1.548736
11	5326301	629327	1.588997	8463481	49	32	5377902	637888	1.567672	8430787	28	52	5426859	646104	1.547738
12	5328763	629733	1.587973	8461932	48	33	5380354	638297	1.566666	8429222	27	53	5429302	646516	1.546751
13	5331224	630139	1.586949	8460381	47	34	5382806	638707	1.565662	8427657	26	54	5431744	646929	1.545764
14	5333685	630546	1.585926	8458830	46	35	5385257	639116	1.564659	8426091	25	55	5434187	647341	1.544779
15	5336145	630953	1.584904	8457278	45	36	5387708	639526	1.563656	8424524	24	56	5436628	647754	1.543794
16	5338605	631359	1.583883	8455726	44	37	5390158	639936	1.562654	8422956	23	57	5439069	648167	1.542810
17	5341065	631766	1.582862	8454172	43	38	5392608	640346	1.561654	8421388	22	58	5441510	648580	1.541828
18	5343523	632173	1.581843	8452618	42	39	5395058	640756	1.560654	8419819	21	59	5443951	648994	1.540846
19	5345982	632581	1.580825	8451064	41	40	5397507	641167	1.559655	8418249	20	60	5446390	649407	1.539865
20	5348440	632988	1.579807	8449508	40									844706	0
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 57.

Deg. 57.

Deg. 57.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

33 Deg.

33 Deg.

33 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'		
0	5446390	649407	1.539865	8386706	60	21	5497520	658127	1.519463	8353279	39	41	5546024	666496	1.500382	8321155	19
1	5448830	649821	1.538884	8385121	59	22	5499950	658544	1.518501	8351680	38	42	5548444	666917	1.499436	8319541	18
2	5451269	650235	1.537905	8383536	58	23	5502379	658961	1.517540	8350080	37	43	5550864	667337	1.498492	8317927	17
3	5453707	650649	1.536927	8381950	57	24	5504807	659378	1.516579	8348479	36	44	5553283	667758	1.497548	8316312	16
4	5456145	651063	1.535949	8380363	56	25	5507236	659796	1.515620	8346877	35	45	5555702	668178	1.496605	8314696	15
5	5458583	651477	1.534972	8378775	55	26	5509663	660213	1.514661	8345275	34	46	5558121	668599	1.495663	8313080	14
6	5461020	651891	1.533996	8377187	54	27	5512091	660631	1.513703	8343672	33	47	5560539	669020	1.494722	8311463	13
7	5463456	652306	1.533021	8375598	53	28	5514518	661049	1.512746	8342068	32	48	5562956	669441	1.493782	8309845	12
8	5465892	652721	1.532047	8374009	52	29	5516944	661467	1.511790	8340463	31	49	5565373	669863	1.492842	8308226	11
9	5468328	653136	1.531074	8372418	51	30	5519370	661885	1.510835	8338858	30	50	5567790	670284	1.491903	8306607	10
10	5470763	653551	1.530102	8370827	50	31	5521795	662304	1.509880	8337252	29	51	5570206	670706	1.490965	8304987	9
11	5473198	653966	1.529130	8369236	49	32	5524220	662722	1.508927	8335646	28	52	5572621	671128	1.490028	8303366	8
12	5475632	654381	1.528160	8367643	48	33	5526645	663141	1.507974	8334038	27	53	5575036	671550	1.489092	8301745	7
13	5478066	654797	1.527190	8366050	47	34	5529069	663560	1.507022	8332430	26	54	5577451	671972	1.488157	8300123	6
14	5480499	655212	1.526221	8364456	46	35	5531492	663979	1.506071	8330822	25	55	5579865	672394	1.487222	8298500	5
15	5482932	655628	1.525253	8362862	45	36	5533915	664398	1.505121	8329212	24	56	5582279	672816	1.486288	8296877	4
16	5485365	656044	1.524286	8361266	44	37	5536338	664817	1.504171	8327602	23	57	5584692	673239	1.485355	8295252	3
17	5487797	656460	1.523320	8359670	43	38	5538760	665237	1.503222	8325991	22	58	5587105	673662	1.484423	8293628	2
18	5490228	656877	1.522354	8358074	42	39	5541182	665657	1.502275	8324380	21	59	5589517	674085	1.483491	8292002	1
19	5492659	657293	1.521389	8356476	41	40	5543603	666076	1.501328	8322768	20	60	5591929	674508	1.482561	8290376	0
20	5495090	657710	1.520426	8354878	40												

Deg. 56.

Deg. 56.

Deg. 56.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

34 Deg.

34 Deg.

34 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	5591929	674508	1482561	8290376	60	21	5642467	683433	1463200	8256082	39	41	5690403	692002	1445081
1	5594340	674931	1481631	8288749	59	22	5644869	683860	1462287	8254420	38	42	5692795	692432	1444183
2	5596751	675355	1480702	8287121	58	23	5647270	684287	1461374	8252778	37	43	5695187	692863	1443286
3	5599162	675779	1479773	8285493	57	24	5649670	684714	1460463	8251135	36	44	5697577	693293	1442389
4	5601572	676202	1478846	8283864	56	25	5652070	685141	1459552	8249491	35	45	5699968	693724	1441494
5	5603981	676626	1477919	8282234	55	26	5654469	685569	1458642	8247847	34	46	5702357	694155	1440599
6	5606390	677050	1476993	8280603	54	27	5656868	685996	1457732	8246202	33	47	5704747	694586	1439704
7	5608798	677475	1476068	8278972	53	28	5659267	686424	1456824	8244556	32	48	5707136	695018	1438811
8	5611206	677899	1475144	8277340	52	29	5661665	686852	1455916	8242909	31	49	5709524	695449	1437918
9	5613614	678324	1474221	8275708	51	30	5664062	687281	1455009	8241262	30	50	5711912	695881	1437026
10	5616021	678749	1473298	8274074	50	31	5666459	687709	1454102	8239614	29	51	5714299	696313	1436135
11	5618428	679174	1472376	8272440	49	32	5668856	688137	1453197	8237965	28	52	5716686	696745	1435245
12	5620834	679599	1471455	8270806	48	33	5671252	688566	1452292	8236316	27	53	5719073	697177	1434355
13	5623239	680024	1470535	8269170	47	34	5673648	688995	1451388	8234666	26	54	5721459	697609	1433466
14	5625645	680450	1469615	8267534	46	35	5676043	689424	1450485	8233015	25	55	5723844	698042	1432578
15	5628049	680875	1468696	8265897	45	36	5678437	689853	1449582	8231364	24	56	5726229	698474	1431690
16	5630453	681301	1467778	8264260	44	37	5680832	690283	1448680	8229712	23	57	5728614	698907	1430803
17	5632857	681727	1466861	8262622	43	38	5683225	690712	1447779	8228059	22	58	5730998	699340	1429917
18	5635260	682153	1465945	8260983	42	39	5685619	691142	1446879	8226405	21	59	5733381	699774	1429032
19	5637663	682580	1465029	8259343	41	40	5688011	691572	1445980	8224751	20	60	5735764	700207	1428148
20	5640066	683006	1464114	8257703	40										1427264
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 55.

Deg. 55.

Deg. 55



## NATURAL SINES AND TANGENTS TO A RADIUS 1.

35 Deg.

35 Deg.

35 Deg.

	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	5735764	700207	1.428148	8191520	60.21	5785696	709350	1.409740	8156330	39.41	5833050	718131	1.392501	8122532	19
1	5738147	700641	1.427264	8189852	59.22	5788069	709787	1.408871	8154647	38.42	5835412	718572	1.391647	8120835	18
2	5740529	701074	1.426381	8188182	58.23	5790440	710225	1.408003	8152993	37.43	5837774	719014	1.390793	8119137	17
3	5742911	701508	1.425498	8186512	57.24	5792812	710663	1.407136	8151278	36.44	5840136	719455	1.389940	8117439	16
4	5745292	701943	1.424617	8184841	56.25	5795183	711100	1.406270	8149593	35.45	5842497	719897	1.389087	8115740	15
5	5747672	702377	1.423736	8183169	55.26	5797553	711539	1.405404	8147906	34.46	5844857	720338	1.388235	8114040	14
6	5750053	702811	1.422856	8181497	54.27	5799923	711977	1.404539	8146220	33.47	5847217	720780	1.387384	8112339	13
7	5752432	703246	1.421976	8179824	53.28	5802292	712415	1.403674	8144532	32.48	5849577	721222	1.386534	8110638	12
8	5754811	703681	1.421097	8178151	52.29	5804661	712854	1.402811	8142844	31.49	5851936	721665	1.385684	8108936	11
9	5757190	704116	1.420220	8176476	51.30	5807030	713293	1.401948	8141155	30.50	5854294	722107	1.384835	8107234	10
10	5759568	704551	1.419342	8174801	50.31	5809397	713732	1.401086	8139466	29.51	5856652	722550	1.383986	8105530	9
11	5761946	704986	1.418466	8173125	49.32	5811765	714171	1.400224	8137775	28.52	5859010	722993	1.383139	8103826	8
12	5764323	705422	1.417590	8171449	48.33	5814132	714610	1.399363	8136084	27.53	5861367	723436	1.382292	8102122	7
13	5766700	705858	1.416715	8169772	47.34	5816498	715050	1.398503	8134393	26.54	5863724	723879	1.381445	8100416	6
14	5769076	706294	1.415840	8168094	46.35	5818864	715489	1.397644	8132701	25.55	5866080	724322	1.380600	8098710	5
15	5771452	706730	1.414967	8166416	45.36	5821230	715929	1.396785	8131008	24.56	5868435	724766	1.379755	8097004	4
16	5773827	707166	1.414094	8164736	44.37	5823595	716369	1.395927	8129314	23.57	5870790	725210	1.378910	8095296	3
17	5776202	707602	1.413222	8163056	43.38	5825959	716810	1.395069	8127620	22.58	5873145	725654	1.378067	8093588	2
18	5778576	708039	1.412350	8161376	42.39	5828323	717250	1.394213	8125925	21.59	5875499	726098	1.377221	8091879	1
19	5780950	708476	1.411479	8159695	41.40	5830687	717691	1.393357	8124229	20.60	5877853	726542	1.376381	8090170	0
20	5783323	708913	1.410609	8158013	40										
	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 54.

Deg. 54.

Deg. 54.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

36 Deg.

36 Deg.

36 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	5877553	726542	1-376381	8090170	60	21-5927163	735917	1-358848	8054113	39	41-5973919	744924	1-342417	8019495	19
1	5880206	726987	1-375540	8088460	59	22-5929505	736366	1-358020	8052389	38	42-5976251	745377	1-341602	8017756	18
2	5882558	727431	1-374699	8086749	58	23-5931847	736814	1-357193	8050664	37	43-5978583	745829	1-340788	8016018	17
3	5884910	727876	1-373859	8085037	57	24-5934189	737263	1-356367	8048938	36	44-5980915	746282	1-339975	8014278	16
4	5887262	728321	1-373019	8083325	56	25-5936530	737712	1-355541	8047211	35	45-5983246	746735	1-339162	8012538	15
5	5889613	728767	1-372180	8081612	55	26-5938871	738162	1-354716	8045484	34	46-5985577	747188	1-338350	8010797	14
6	5891964	729212	1-371342	8079899	54	27-5941211	738611	1-353891	8043756	33	47-5987906	747642	1-337538	8009056	13
7	5894314	729658	1-370504	8078185	53	28-5943550	739061	1-353068	8042028	32	48-5990236	748095	1-336727	8007314	12
8	5896663	730104	1-369667	8076470	52	29-5945889	739511	1-352244	8040299	31	49-5992565	748549	1-335917	8005571	11
9	5899012	730550	1-368831	8074754	51	30-5948228	739961	1-351422	8038569	30	50-5994893	749003	1-335107	8003827	10
10	5901361	730996	1-367995	8073038	50	31-5950566	740411	1-350600	8036838	29	51-5997221	749457	1-334298	8002083	9
11	5903709	731442	1-367161	8071321	49	32-5952904	740861	1-349779	8035107	28	52-5999549	749911	1-333490	8000338	8
12	5906057	731889	1-366326	8069603	48	33-5955241	741312	1-348958	8033375	27	53-6001876	750366	1-332682	7998593	7
13	5908404	732336	1-365493	8067885	47	34-5957577	741763	1-348139	8031642	26	54-6004202	750821	1-331875	7996847	6
14	5910750	732783	1-364660	8066166	46	35-5959913	742214	1-347319	8029909	25	55-6006528	751276	1-331068	7995100	5
15	5913096	733230	1-363827	8064446	45	36-5962249	742665	1-346501	8028175	24	56-6008854	751731	1-330262	7993352	4
16	5915442	733677	1-362996	8062726	44	37-5964584	743117	1-345683	8026440	23	57-6011179	752186	1-329457	7991604	3
17	5917787	734125	1-362165	8061005	43	38-5966918	743568	1-344865	8024705	22	58-6013503	752642	1-328652	7989855	2
18	5920132	734573	1-361335	8059283	42	39-5969252	744020	1-344049	8022969	21	59-6015827	753098	1-327848	7988105	1
19	5922476	735021	1-360505	8057560	41	40-5971586	744472	1-343233	8021232	20	60-6018150	753554	1-327044	7986355	0
20	5924819	735469	1-359676	8055837	40										

Deg. 53.

Deg. 53.

Deg. 53.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

37 Deg.

37 Deg.

37 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	.6018150	.753554	1.327044	.7986355	6021	.6066624	.763175	1.310314	.7949444	3941	.6112969	.772423	1.294627	.7914014	19
1	.6020473	.754010	1.326242	.7984604	5922	.6089136	.763636	1.309523	.7947678	3842	.6115270	.772887	1.293948	.7912235	18
2	.6022795	.754466	1.325439	.7982853	5823	.6071447	.764096	1.308734	.7945913	3743	.6117572	.773352	1.293071	.7910456	17
3	.6025117	.754923	1.324638	.7981100	5724	.6073758	.764557	1.307945	.7944146	3644	.6119873	.773817	1.292294	.7908676	16
4	.6027439	.755379	1.323837	.7979347	5625	.6076069	.765018	1.307157	.7942379	3545	.6122173	.774282	1.291517	.7906896	15
5	.6029760	.755836	1.323036	.7977594	5526	.6078379	.765480	1.306369	.7940611	3446	.6124473	.774748	1.290742	.7905115	14
6	.6032080	.756294	1.322237	.7975839	5427	.6080689	.765941	1.305582	.7938843	3347	.6126772	.775213	1.289966	.7903333	13
7	.6034400	.756751	1.321437	.7974084	5328	.6082998	.766403	1.304796	.7937074	3248	.6129071	.775679	1.289192	.7901550	12
8	.6036719	.757209	1.320639	.7972329	5229	.6085306	.766864	1.304010	.7935304	3149	.6131369	.776145	1.288418	.7899767	11
9	.6039038	.757666	1.319841	.7970572	5130	.6087614	.767327	1.303225	.7933533	3050	.6133666	.776611	1.287644	.7897983	10
10	.6041356	.758124	1.319044	.7968815	5031	.6089922	.767789	1.302440	.7931762	2951	.6135964	.777078	1.286871	.7896198	9
11	.6043674	.758582	1.318247	.7967058	4932	.6092229	.768251	1.301656	.7929990	2852	.6138260	.777544	1.286099	.7894413	8
12	.6045991	.759041	1.317451	.7965299	4833	.6094535	.768714	1.300873	.7928218	2753	.6140556	.778011	1.285327	.7892627	7
13	.6048308	.759499	1.316655	.7963540	4734	.6096841	.769177	1.300090	.7926445	2654	.6142852	.778478	1.284556	.7890841	6
14	.6050624	.759958	1.315861	.7961780	4635	.6099147	.769640	1.299308	.7924671	2555	.6145147	.778946	1.283786	.7889054	5
15	.6052940	.760417	1.315066	.7960020	4536	.6101452	.770103	1.298526	.7922896	2456	.6147442	.779413	1.283016	.7887266	4
16	.6055255	.760876	1.314273	.7958259	4437	.6103756	.770567	1.297745	.7921121	2357	.6149736	.779881	1.282246	.7885477	3
17	.6057570	.761336	1.313480	.7956497	4338	.6106060	.771030	1.296964	.7919345	2258	.6152029	.780349	1.281477	.7883688	2
18	.6059884	.761795	1.312687	.7954735	4239	.6108363	.771494	1.296185	.7917569	2159	.6154322	.780817	1.280709	.7881898	1
19	.6062198	.762255	1.311895	.7952972	4140	.6110666	.771958	1.295405	.7915792	2060	.6156615	.781285	1.279941	.7880108	0
20	.6064511	.762715	1.311104	.7951208	40										

Deg. 52.

Deg. 52.

Deg. 52.

# NATURAL SINES AND TANGENTS TO A RADIUS 1.

38 Deg.

38 Deg.

38 Deg.

°	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	6156615	781285	1.279941	7880108	60	21	6204636	791170	1.263950	7842352	39	41	6250156	800673	1.248948
1	6158907	781754	1.279174	7878316	59	22	6206917	791643	1.263195	7840547	38	42	6252427	801151	1.248204
2	6161198	782222	1.278407	7876524	58	23	6209198	792116	1.262440	7838741	37	43	6254696	801628	1.247460
3	6163489	782691	1.277641	7874732	57	24	6211478	792590	1.261686	7836935	36	44	6256966	802106	1.246716
4	6165780	783161	1.276876	7872939	56	25	6213757	793064	1.260932	7835127	35	45	6259235	802584	1.245974
5	6168069	783630	1.276111	7871145	55	26	6216036	793537	1.260179	7833320	34	46	6261503	803063	1.245232
6	6170359	784100	1.275347	7869350	54	27	6218314	794012	1.259426	7831511	33	47	6263771	803541	1.244490
7	6172648	784570	1.274583	7867555	53	28	6220592	794486	1.258674	7829702	32	48	6266038	804020	1.243749
8	6174936	785040	1.273820	7865759	52	29	6222870	794961	1.257923	7827892	31	49	6268305	804499	1.243008
9	6177224	785510	1.273057	7863963	51	30	6225146	795435	1.257172	7826082	30	50	6270571	804979	1.242268
10	6179511	785980	1.272295	7862165	50	31	6227423	795911	1.256421	7824270	29	51	6272837	805458	1.241529
11	6181798	786451	1.271534	7860367	49	32	6229698	796386	1.255672	7822459	28	52	6275102	805938	1.240790
12	6184084	786922	1.270773	7858569	48	33	6231974	796861	1.254922	7820646	27	53	6277366	806418	1.240051
13	6186370	787393	1.270013	7856770	47	34	6234248	797337	1.254174	7818833	26	54	6279631	806898	1.239313
14	6188655	787864	1.269253	7854970	46	35	6236522	797813	1.253426	7817019	25	55	6281894	807378	1.238576
15	6190939	788336	1.268494	7853169	45	36	6238796	798289	1.252678	7815205	24	56	6284157	807859	1.237839
16	6193224	788808	1.267735	7851368	44	37	6241069	798765	1.251931	7813390	23	57	6286420	808340	1.237103
17	6195507	789280	1.266977	7849566	43	38	6243342	799242	1.251184	7811574	22	58	6288682	808821	1.236367
18	6197790	789752	1.266219	7847764	42	39	6245614	799719	1.250438	7809757	21	59	6290943	809302	1.235631
19	6200073	790224	1.265462	7845961	41	40	6247885	800196	1.249693	7807940	20	60	6293204	809784	1.234897
20	6202355	790697	1.264706	7844157	40										

Deg. 51.

Deg. 51.

Deg. 51.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

39 Deg.

39 Deg.

39 Deg.

/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/	Sine.	Tang.	Cotang.	Cosine.	/
0	.6293204	.809784	1.234897	.7771460	60	.21	.6340559	.819948	1.219588	.7732872	39	.41	.6385440	.829724	1.205219
1	.6295464	.810265	1.234162	.7769629	59	.22	.6342808	.820435	1.218865	.7731027	38	.42	.6387678	.830216	1.204505
2	.6297724	.810747	1.233429	.7767797	58	.23	.6345057	.820922	1.218142	.7729182	37	.43	.6389916	.830707	1.203793
3	.6299983	.811230	1.232696	.7765965	57	.24	.6347305	.821409	1.217419	.7727336	36	.44	.6392153	.831199	1.203081
4	.6302242	.811712	1.231963	.7764132	56	.25	.6349553	.821896	1.216698	.7725489	35	.45	.6394390	.831691	1.202369
5	.6304500	.812195	1.231231	.7762298	55	.26	.6351800	.822384	1.215976	.7723642	34	.46	.6396626	.832183	1.201658
6	.6306758	.812678	1.230499	.7760464	54	.27	.6354046	.822871	1.215256	.7721794	33	.47	.6398862	.832675	1.200947
7	.6309015	.813161	1.229768	.7758629	53	.28	.6356292	.823359	1.214535	.7719945	32	.48	.6401097	.833168	1.200237
8	.6311272	.813644	1.229038	.7756794	52	.29	.6358537	.823847	1.213816	.7718096	31	.49	.6403332	.833661	1.199527
9	.6313528	.814128	1.228308	.7754957	51	.30	.6360782	.824336	1.213097	.7716246	30	.50	.6405566	.834154	1.198818
10	.6315784	.814611	1.227578	.7753121	50	.31	.6363026	.824825	1.212378	.7714395	29	.51	.6407799	.834648	1.198109
11	.6318039	.815095	1.226849	.7751283	49	.32	.6365270	.825314	1.211660	.7712544	28	.52	.6410032	.835141	1.197401
12	.6320293	.815580	1.226121	.7749445	48	.33	.6367513	.825803	1.210942	.7710692	27	.53	.6412264	.835635	1.196693
13	.6322547	.816064	1.225393	.7747606	47	.34	.6369756	.826292	1.210225	.7708840	26	.54	.6414496	.836129	1.195986
14	.6324800	.816549	1.224665	.7745767	46	.35	.6371999	.826782	1.209508	.7706986	25	.55	.6416728	.836624	1.195279
15	.6327053	.817034	1.223938	.7743926	45	.36	.6374240	.827271	1.208792	.7705132	24	.56	.6418958	.837118	1.194573
16	.6329306	.817519	1.223212	.7742086	44	.37	.6376481	.827762	1.208076	.7703278	23	.57	.6421189	.837613	1.193867
17	.6331557	.818004	1.222486	.7740244	43	.38	.6378721	.828252	1.207361	.7701423	22	.58	.6423418	.838108	1.193162
18	.6333809	.818490	1.221761	.7738402	42	.39	.6380961	.828742	1.206646	.7699567	21	.59	.6425647	.838604	1.192457
19	.6336059	.818976	1.221036	.7736559	41	.40	.6383201	.829233	1.205932	.7697710	20	.60	.6427876	.839099	1.191753
20	.6338310	.819462	1.220312	.7734716	40									.839594	.7660444
/	Cosine.	Cotang.	Tang.	Sine.	/	Cosine.	Cotang.	Tang.	Sine.	/	Cosine.	Cotang.	Tang.	Sine.	/

Deg. 50.

Deg. 50.

Deg. 50.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

40 Deg.

40 Deg.

40 Deg.

	Sine.	Tang.	Cotang.	Cosine.	/	/	Sine.	Tang.	Cotang.	Cosine.	/	/	Sine.	Tang.	Cotang.	Cosine.	/
0	.6427876	.839099	1.191753	.7660444	60	21	.6474551	.849563	1.177075	.7631036	39	41	.6518778	.859629	1.163291	.7583240	19
1	.6430104	.839595	1.191049	.7658574	59	22	.6476767	.850064	1.176382	.7619152	38	42	.6520984	.860135	1.162607	.7581343	18
2	.6432332	.840091	1.190346	.7656704	58	23	.6478984	.850565	1.175688	.7617268	37	43	.6523189	.860641	1.161923	.7579446	17
3	.6434559	.840587	1.189643	.7654832	57	24	.6481199	.851066	1.174996	.7615383	36	44	.6525394	.861148	1.161240	.7577548	16
4	.6436785	.841084	1.188941	.7652960	56	25	.6483314	.851568	1.174303	.7613497	35	45	.6527598	.861655	1.160557	.7575650	15
5	.6439011	.841581	1.188239	.7651087	55	26	.6485428	.852070	1.173612	.7611611	34	46	.6529801	.862162	1.159874	.7573751	14
6	.6441236	.842078	1.187538	.7649214	54	27	.6487842	.852572	1.172920	.7609724	33	47	.6532004	.862669	1.159192	.7571851	13
7	.6443461	.842575	1.186837	.7647340	53	28	.6490056	.853075	1.172229	.7607837	32	48	.6534206	.863176	1.158511	.7569951	12
8	.6445685	.843073	1.186136	.7645465	52	29	.6492268	.853577	1.171539	.7605949	31	49	.6536408	.863684	1.157830	.7568050	11
9	.6447909	.843570	1.185437	.7643590	51	30	.6494480	.854080	1.170849	.7604060	30	50	.6538609	.864192	1.157149	.7566148	10
10	.6450132	.844068	1.184737	.7641714	50	31	.6496692	.854583	1.170160	.7602170	29	51	.6540810	.864700	1.156469	.7564246	9
11	.6452355	.844567	1.184038	.7639838	49	32	.6498903	.855087	1.169471	.7600280	28	52	.6543010	.865209	1.155789	.7562343	8
12	.6454577	.845065	1.183340	.7637960	48	33	.6501114	.855591	1.168782	.7598389	27	53	.6545209	.865718	1.155110	.7560439	7
13	.6456798	.845564	1.182642	.7636082	47	34	.6503324	.856095	1.168094	.7596498	26	54	.6547408	.866227	1.154431	.7558535	6
14	.6459019	.846063	1.181944	.7634204	46	35	.6505533	.856599	1.167407	.7594606	25	55	.6549607	.866736	1.153753	.7556630	5
15	.6461240	.846562	1.181247	.7632325	45	36	.6507742	.857103	1.166720	.7592713	24	56	.6551804	.867246	1.153075	.7554724	4
16	.6463460	.847062	1.180551	.7630445	44	37	.6509951	.857608	1.166033	.7590820	23	57	.6554002	.867755	1.152397	.7552818	3
17	.6465679	.847561	1.179855	.7628564	43	38	.6512158	.858113	1.165347	.7588926	22	58	.6556198	.868265	1.151721	.7550911	2
18	.6467898	.848061	1.179159	.7626683	42	39	.6514366	.858618	1.164661	.7587031	21	59	.6558395	.868776	1.151044	.7549004	1
19	.6470116	.848561	1.178464	.7624802	41	40	.6516572	.859124	1.163976	.7585136	20	60	.6560590	.869286	1.150368	.7547096	0
20	.6472334	.849062	1.177769	.7622919	40												

Deg. 49.

Deg. 49.

Deg. 49.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

41 Deg.

41 Deg.

41 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	.6560590	.869286	1.150368	.7547096	60	.21	.6606570	.880068	1.136274	.7506879	39	.41	.6650131	.890445	1.123032
1	.6565785	.869797	1.149692	.7545187	59	.22	.6608754	.880585	1.135608	.7504957	38	.42	.6652304	.890967	1.122375
2	.6564980	.870308	1.149017	.7543278	58	.23	.6610936	.881101	1.134942	.7503034	37	.43	.6654475	.891489	1.121718
3	.6567174	.870820	1.148342	.7541368	57	.24	.6613119	.881618	1.134277	.7501111	36	.44	.6656646	.892011	1.121061
4	.6569367	.871331	1.147668	.7539457	56	.25	.6615300	.882135	1.133612	.7499187	35	.45	.6658817	.892534	1.120405
5	.6571560	.871843	1.146994	.7537546	55	.26	.6617482	.882653	1.132947	.7497262	34	.46	.6660987	.893056	1.119749
6	.6573752	.872355	1.146321	.7535634	54	.27	.6619662	.883170	1.132283	.7495337	33	.47	.6663156	.893579	1.119094
7	.6575944	.872868	1.145648	.7533721	53	.28	.6621842	.883688	1.131620	.7493411	32	.48	.6665325	.894103	1.118439
8	.6578135	.873380	1.144976	.7531808	52	.29	.6624022	.884206	1.130957	.7491484	31	.49	.6667493	.894626	1.117784
9	.6580326	.873893	1.144304	.7529894	51	.30	.6626202	.884725	1.130294	.7489557	30	.50	.6669661	.895150	1.117130
10	.6582516	.874406	1.143632	.7527980	50	.31	.6628379	.885244	1.129632	.7487639	29	.51	.6671828	.895674	1.116476
11	.6584706	.874920	1.142961	.7526065	49	.32	.6630557	.885763	1.128970	.7485701	28	.52	.6673994	.896199	1.115823
12	.6586895	.875433	1.142290	.7524149	48	.33	.6632734	.886282	1.128308	.7483772	27	.53	.6676160	.896723	1.115170
13	.6589083	.875947	1.141620	.7522233	47	.34	.6634910	.886801	1.127647	.7481842	26	.54	.6678326	.897248	1.114518
14	.6591271	.876462	1.140950	.7520316	46	.35	.6637087	.887321	1.126987	.7479912	25	.55	.6680490	.897773	1.113866
15	.6593458	.876976	1.140281	.7518398	45	.36	.6639262	.887841	1.126327	.7477981	24	.56	.6682655	.898299	1.113214
16	.6595645	.877491	1.139612	.7516480	44	.37	.6641437	.888361	1.125667	.7476049	23	.57	.6684818	.898825	1.112563
17	.6597831	.878006	1.138944	.7514561	43	.38	.6643612	.888882	1.125008	.7474117	22	.58	.6686981	.899351	1.111912
18	.6600017	.878521	1.138276	.7512641	42	.39	.6645785	.889403	1.124349	.7472184	21	.59	.6689144	.899877	1.111262
19	.6602202	.879037	1.137608	.7510721	41	.40	.6647959	.889924	1.123690	.7470251	20	.60	.6691306	.900404	1.110612
20	.6604386	.879552	1.136941	.7508800	40										1.110612
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'

Deg. 48.

Deg. 48.

Deg. 48.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

42 Deg.

42 Deg.

42 Deg.

	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	6691306	900404	1.110612	7431448	60	21	6736577	911526	1.097060	7390435	39	41	6779459	922235	1.084322
1	6693468	900930	1.109963	7429502	59	22	6738727	912059	1.096420	7388475	38	42	6781597	922773	1.083689
2	6695628	901458	1.109314	7427554	58	23	6740876	912592	1.095779	7386515	37	43	6783734	923312	1.083057
3	6697789	901985	1.108665	7425606	57	24	6743024	913125	1.095139	7384553	36	44	6785871	923851	1.082425
4	6699948	902513	1.108017	7423658	56	25	6745172	913659	1.094500	7382592	35	45	6788007	924390	1.081793
5	6702108	903041	1.107369	7421708	55	26	6747319	914192	1.093861	7380629	34	46	6790143	924930	1.081162
6	6704266	903569	1.106721	7419758	54	27	6749466	914727	1.093222	7378666	33	47	6792278	925470	1.080532
7	6706424	904097	1.106075	7417808	53	28	6751612	915261	1.092584	7376703	32	48	6794413	926010	1.079901
8	6708582	904626	1.105428	7415857	52	29	6753757	915796	1.091946	7374738	31	49	6796547	926550	1.079271
9	6710739	905155	1.104782	7413905	51	30	6755902	916331	1.091308	7372773	30	50	6798681	927091	1.078642
10	6712895	905685	1.104136	7411953	50	31	6758046	916866	1.090671	7370808	29	51	6800813	927632	1.078013
11	6715051	906214	1.103491	7410000	49	32	6760190	917402	1.090034	7368842	28	52	6802946	928173	1.077384
12	6717206	906744	1.102846	7408046	48	33	6762333	917937	1.089398	7366875	27	53	6805078	928715	1.076756
13	6719361	907274	1.102201	7406092	47	34	6764476	918474	1.088762	7364908	26	54	6807209	929257	1.076128
14	6721515	907805	1.101557	7404137	46	35	6766618	919010	1.088126	7362940	25	55	6809339	929799	1.075500
15	6723668	908336	1.100914	7402181	45	36	6768760	919547	1.087491	7360971	24	56	6811469	930342	1.074873
16	6725821	908867	1.100270	7400225	44	37	6770901	920084	1.086857	7359002	23	57	6813599	930884	1.074246
17	6727973	909398	1.099628	7398268	43	38	6773041	920621	1.086222	7357032	22	58	6815728	931428	1.073620
18	6730125	909930	1.098985	7396311	42	39	6775181	921159	1.085588	7355061	21	59	6817856	931971	1.072994
19	6732276	910461	1.098343	7394353	41	40	6777320	921696	1.084955	7353090	20	60	6819984	932515	1.072368
20	6734427	910994	1.097702	7392394	40										
	Cosine.	Cotang.	Tang.	Sine.	'		Cosine.	Cotang.	Tang.	Sine.	'		Cosine.	Cotang.	Tang.

Deg. 47.

Deg. 47.

Deg. 47.



## NATURAL SINES AND TANGENTS TO A RADIUS 1.

43 Deg.

43 Deg.

43 Deg.

'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'		
0	6819984	932515	1-072368	7313537	60	21	6864532	944001	1-059320	7271740	39	41	6906721	955064	1-047049	7231681	19
1	6822111	933059	1-071743	7311553	59	22	6866647	944551	1-058703	7269743	38	42	6908824	955620	1-046440	7229671	18
2	6824237	933603	1-071118	7309568	58	23	6868761	945102	1-058086	7267745	37	43	6910927	956177	1-045831	7227661	17
3	6826363	934147	1-070494	7307583	57	24	6870875	945653	1-057470	7265747	36	44	6913029	956734	1-045222	7225651	16
4	6828489	934692	1-069870	7305597	56	25	6872988	946204	1-056854	7263748	35	45	6915131	957291	1-044613	7223640	15
5	6830613	935238	1-069246	7303610	55	26	6875101	946755	1-056238	7261748	34	46	6917232	957849	1-044005	7221628	14
6	6832738	935783	1-068623	7301623	54	27	6877213	947307	1-055623	7259748	33	47	6919332	958407	1-043397	7219615	13
7	6834861	936329	1-068000	7299635	53	28	6879325	947859	1-055008	7257747	32	48	6921432	958965	1-042790	7217602	12
8	6836984	936875	1-067377	7297646	52	29	6881435	948411	1-054394	7255746	31	49	6923531	959524	1-042183	7215589	11
9	6839107	937421	1-066755	7295657	51	30	6883546	948964	1-053780	7253744	30	50	6925630	960082	1-041576	7213574	10
10	6841229	937968	1-066134	7293668	50	31	6885655	949517	1-053166	7251741	29	51	6927728	960642	1-040970	7211559	9
11	6843350	938515	1-065512	7291677	49	32	6887765	950070	1-052553	7249738	28	52	6929825	961201	1-040364	7209544	8
12	6845471	939062	1-064891	7289686	48	33	6889873	950624	1-051940	7247734	27	53	6931922	961761	1-039758	7207528	7
13	6847591	939610	1-064271	7287695	47	34	6891981	951178	1-051327	7245729	26	54	6934018	962321	1-039153	7205511	6
14	6849711	940157	1-063651	7285703	46	35	6894089	951732	1-050715	7243724	25	55	6936114	962881	1-038548	7203494	5
15	6851830	940706	1-063031	7283710	45	36	6896195	952287	1-050103	7241719	24	56	6938209	963442	1-037944	7201476	4
16	6853948	941254	1-062411	7281716	44	37	6898302	952842	1-049492	7239712	23	57	6940304	964003	1-037340	7199457	3
17	6856066	941803	1-061792	7279722	43	38	6900407	953397	1-048880	7237705	22	58	6942398	964565	1-036736	7197438	2
18	6858184	942352	1-061174	7277728	42	39	6902512	953952	1-048270	7235698	21	59	6944491	965126	1-036133	7195418	1
19	6860300	942901	1-060556	7275732	41	40	6904617	954508	1-047659	7233690	20	60	6946584	965688	1-035530	7193398	0
20	6862416	943451	1-059938	7273736	40												
'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'	Cosine.	Cotang.	Tang.	Sine.	'		

Deg. 16.

Deg. 46.

Deg. 46.

## NATURAL SINES AND TANGENTS TO A RADIUS 1.

44 Deg.

44 Deg.

44 Deg.

	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'	Sine.	Tang.	Cotang.	Cosine.	'
0	.6946584	.965688	1.035530	.7193398	60	.21	.6990396	.977564	1.022950	.7150830	39	.41	.7031879	.989006	1.011115
1	.6948676	.966251	1.034927	.7191377	59	.22	.6992476	.978133	1.022355	.7148796	38	.42	.7033947	.989582	1.010527
2	.6950767	.966813	1.034325	.7189355	58	.23	.6994555	.978702	1.021760	.7146762	37	.43	.7036014	.990158	1.009939
3	.6952858	.967376	1.033723	.7187333	57	.24	.6996633	.979272	1.021166	.7144727	36	.44	.7038081	.990734	1.009352
4	.6954949	.967939	1.033122	.7185310	56	.25	.6998711	.979842	1.020562	.7142691	35	.45	.7040147	.991311	1.008764
5	.6957039	.968503	1.032520	.7183287	55	.26	.7000789	.980412	1.019978	.7140655	34	.46	.7042213	.991888	1.008178
6	.6959128	.969067	1.031919	.7181263	54	.27	.7002866	.980983	1.019385	.7138618	33	.47	.7044278	.992465	1.007591
7	.6961217	.969631	1.031319	.7179238	53	.28	.7004942	.981554	1.018792	.7136581	32	.48	.7046342	.993042	1.007005
8	.6963305	.970196	1.030719	.7177213	52	.29	.7007018	.982125	1.018199	.7134543	31	.49	.7048406	.993620	1.006420
9	.6965392	.970761	1.030119	.7175187	51	.30	.7009093	.982697	1.017607	.7132504	30	.50	.7050469	.994199	1.005834
10	.6967479	.971326	1.029520	.7173161	50	.31	.7011167	.983269	1.017015	.7130465	29	.51	.7052532	.994777	1.005249
11	.6969565	.971891	1.028921	.7171134	49	.32	.7013241	.983841	1.016423	.7128426	28	.52	.7054594	.995356	1.004665
12	.6971651	.972457	1.028322	.7169106	48	.33	.7015314	.984414	1.015832	.7126385	27	.53	.7056655	.995935	1.004080
13	.6973736	.973023	1.027724	.7167078	47	.34	.7017387	.984987	1.015241	.7124344	26	.54	.7058716	.996515	1.003496
14	.6975821	.973590	1.027126	.7165049	46	.35	.7019459	.985560	1.014651	.7122303	25	.55	.7060776	.997095	1.002913
15	.6977905	.974156	1.026528	.7163019	45	.36	.7021531	.986133	1.014061	.7120260	24	.56	.7062835	.997675	1.002329
16	.6979988	.974724	1.025931	.7160989	44	.37	.7023601	.986707	1.013471	.7118218	23	.57	.7064894	.998256	1.001746
17	.6982071	.975291	1.025334	.7158959	43	.38	.7025672	.987282	1.012881	.7116174	22	.58	.7066953	.998837	1.001164
18	.6984153	.975859	1.024738	.7156927	42	.39	.7027741	.987856	1.012292	.7114130	21	.59	.7069011	.999418	1.000581
19	.6986234	.976427	1.024141	.7154895	41	.40	.7029811	.988431	1.011703	.7112086	20	.60	.7071068	1.000000	1.000000
20	.6988315	.976995	1.023546	.7152863	40										

Deg. 45.

Deg. 45.

Deg. 45.









THIS BOOK IS DUE ON THE LAST DATE  
STAMPED BELOW

**AN INITIAL FINE OF 25 CENTS**

WILL BE ASSESSED FOR FAILURE TO RETURN  
THIS BOOK ON THE DATE DUE. THE PENALTY  
WILL INCREASE TO 50 CENTS ON THE FOURTH  
DAY AND TO \$1.00 ON THE SEVENTH DAY  
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